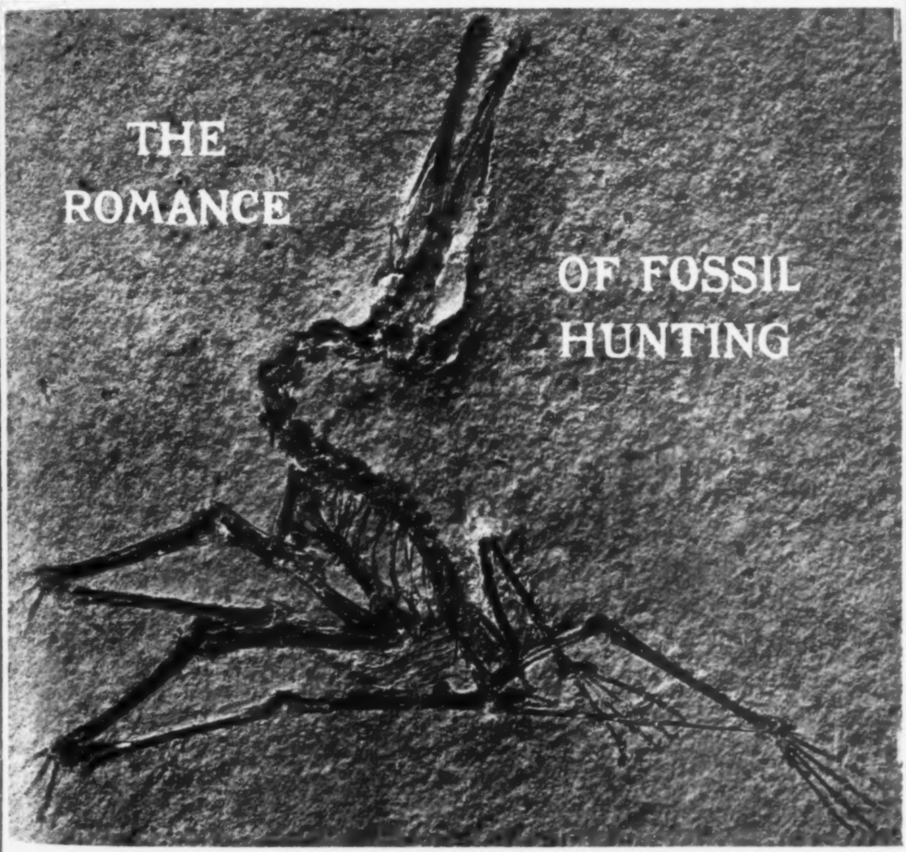
Vol. XXVI SEPTEMBER-OCTOBER, 1926 No. 5

NATURAL HISTORY



JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY

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NATURAL HISTORY

THE JOURNAL OF THE AMERICAN MUSEUM

DEVOTED TO NATURAL HISTORY, EXPLORATION, AND THE DEVELOPMENT OF PUBLIC EDUCATION THROUGH THE MUSEUM

THE ROMANCE OF FOSSIL HUNTING

CHESTER A. REEDS, EDITOR

SEPTEMBER-OCTOBER, 1926

[Published October, 1926]

VOLUME XXVI, NUMBER 5

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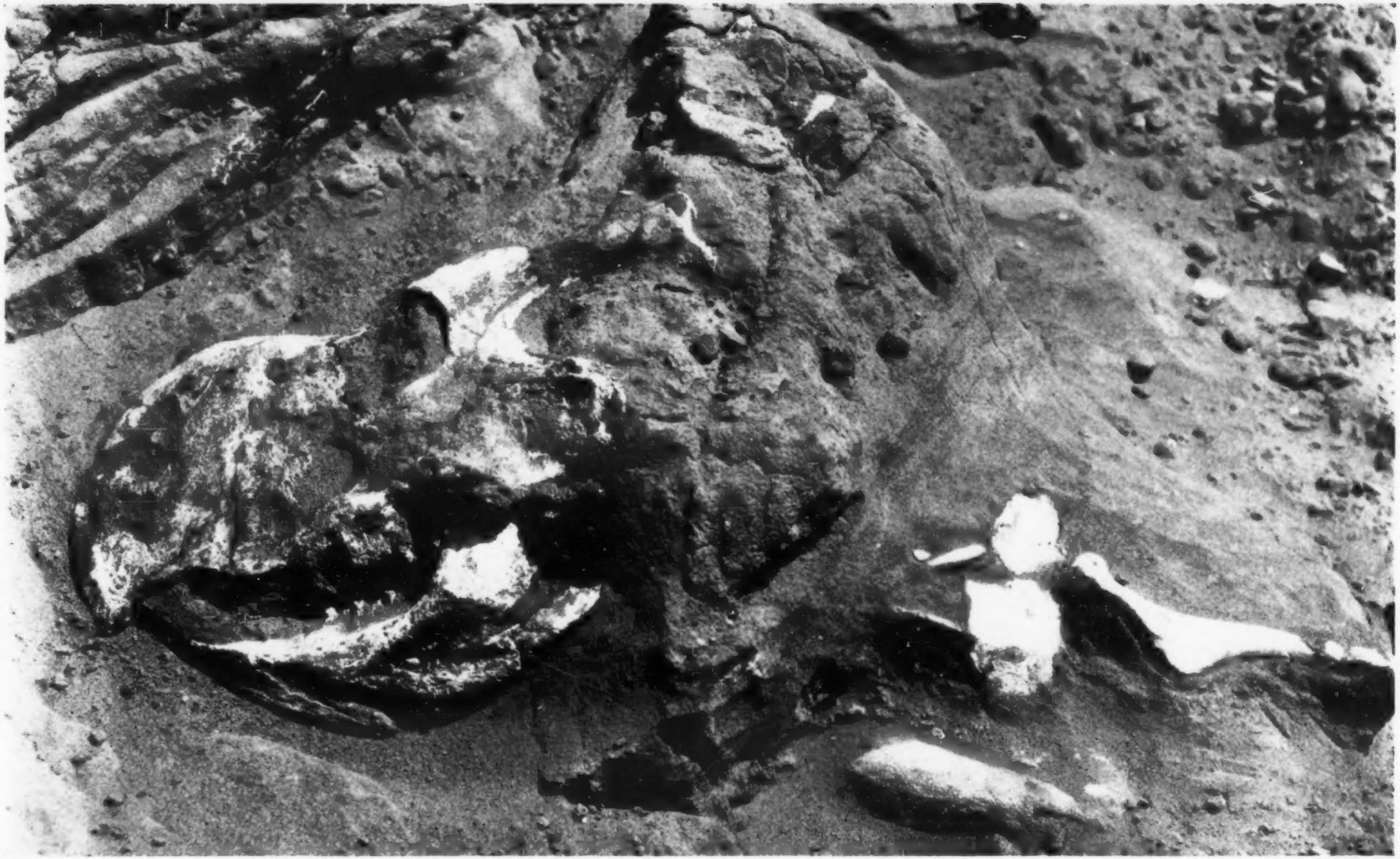


A DINOSAUR SKULL IN THE BEDROCK AT SHABARAKH USU, MONGOLIA

The rock is a fine red sandstone, which, in Cretaceous time, was loose wind-blown sand. An almost perfect skull of *Protoceratops andrewsi* has been chiseled out and cleaned enough for a photograph, showing the curved parrot-like beak and the lower jaw. This is one of the most important types found by the Expedition for it has certain primitive characters and is not known from any other region

enough for a photograph, showing the curved parrot-like beak and the lower jaw. This is one of the most important types found by the Expedition for it has certain primitive characters and is not known from any other region

NATURAL HISTORY

VOLUME XXVI SEPTEMBER–OCTOBER, 1926 NUMBER 5

Cleveland Hoadley Dodge
1860–1926

By HENRY FAIRFIELD OSBORN

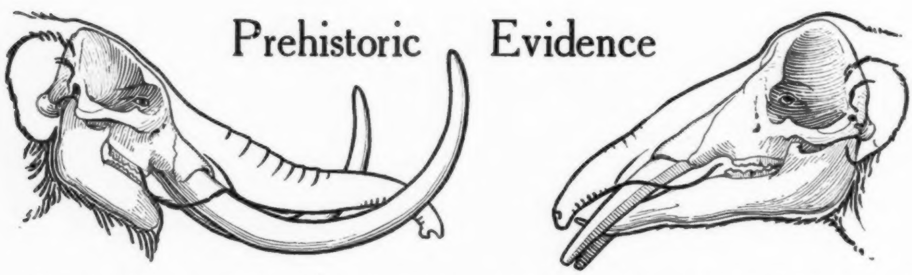
THOSE who recall Cleveland Dodge only in the closing years of his life, will find it hard to picture him in the vigor of his youth at Princeton University and in the confident strength of his young and mature manhood in the life of New York. A classmate of the brilliant Woodrow Wilson, he became his strongest champion in the crisis of the presidency of Princeton University and in the far greater crisis of the presidency of the United States. He backed Wilson at Princeton by his moral and financial support of the Preceptorial System and by his gift of the superb building devoted to Geology and Biology. No president of our country ever enjoyed more unswerving personal support than Cleveland Dodge gave to Woodrow Wilson and to all the great reforms and causes which he espoused.

As a philanthropist in New York, his apparently limitless energy led to the development, on a thoroughly modern religious as well as practical basis, of the Young Men's Christian Association, a movement first conceived by his older brother, Earl Dodge, who also was a graduate of the Princeton Class of 1879. In more recent years he took up the apparently hopeless cause of Relief in the Near East and contributed lavishly of his time, his energy, and his means. He also gave strong financial support to the American University of Beirut.

From his entrance into the service of the American Museum of Natural History on January 21, 1898, until the last days of his life in the spring of 1926, he was an ardent and most generous supporter of all the great causes of the Museum which fell within his special field of interest and of taste—from the fossil fishes under Bashford Dean, to the Congo Expedition, to the African elephant group, to the Roosevelt South American Expedition, to the ill-fated Crocker Land Expedition, to the Central Asiatic Expeditions, to the Special Educational Fund, and finally to the Ralph Winfred Tower Memorial Fund. His contributions and gifts exceed $108,000.

At meetings of the trustees, he was at once the most conservative in matters of finance and of economy and the most progressive in matters of exploration and educational advance. For many years a member of the Executive Committee, he rarely missed a meeting and, soon after his election as a member of this central Committee, rose to the rank of vice president in which office he served for the sixteen-year period, 1908 to 1924. He was the first to applaud a piece of meritorious work by a member of the scientific staff, the first to offer a resolution of appreciation of an administrative achievement. To the president and, in fact, to all the members of the American Museum of Natural History, the life of Cleveland H. Dodge is an inspiration. We find new courage, new enthusiasm, and new confidence in our great undertaking when we contemplate his courage, his enthusiasm, and his confidence.

Prehistoric Evidence



Short-jawed low-fronted *Mastodon* from the Pleistocene of New York State, and long-jawed high-fronted mastodon (*Trilophodon*) from the Miocene of New Mexico, reconstructed upon scaled drawings of fossils skulls

By CHILDS FRICK

Research Associate in Palæontology, American Museum

THE wanderer in Florence, thrilled by the glories of the Renaissance and by antiquities of mediæval, Roman, Grecian, and Etruscan ages, is seldom aware of far older relics that evidence the life of earlier prehistoric centuries. Few sight-seers are conscious of the existence, within a stone's throw of the San Marcos cloisters with their Fra Angelicos and Savonarola's cell, of the R. Instituto with its collection of Pleistocene mammals[1] rivaling both in variety and in individual interest those of the far-famed California tar pools of Rancho-la-Brea.[2] Here may be seen and studied the petrified remains of strange, but none the less real, creatures that in relatively recent prehistoric time bred and held sway in what is now the valley of the Arno. Well may we wish that those famed Florentine collectors and princes, the Medici, had themselves but realized the rich evidence buried under foot, and dared the prejudice of the time of Galileo to foster in that early day the gathering together of these mute witnesses of a former era, and thus had advanced the present status of our science by hundreds of years: a science whose aim is the history of animal forms; the tracing back of family trees of the creatures of today and of the extinct creatures of the past, not by generations but by steps of many thousands of years; the causes of their differentiation, and the records and bearing of their migrations on the physical history of the earth: a science whose evidence is the fossilized remains of the great epochs of the past, those different animal assemblages met with in consecutive superimposed layers of the earth's crust,—remains that ere the investigation is complete must represent Life throughout the ages on every continent and in all its faunal zones: a methodical science that deals with the tabulation and description of these varied assemblages and with the intercomparison of all,—the relative levels at which the present-day associates of men first appear, the species from lower levels that suggest the ancestral stems of each of these, the uppermost limits of survival of the extinct forms of ages past, and the light that all this throws on the origin of man.

The current number of NATURAL HISTORY is given to the romance of our hunt for these fossilized remains throughout many lands. In the following pages, therefore, I have sought to illustrate several of the varied ways

[1]Museum Geologico, R. Instituto di Studi Superiori, Director Dr. Giotto Dainelli.

[2]See "Mammals and Birds of the California Tar Pools," Osborn, H. F., NATURAL HISTORY, XXV, No. 6, p. 527.

in which such evidence occurs by telling of three localities visited in the past year. "Where do you hunt?" "How deep do you dig?" are oft-repeated queries. As the first of these three examples I take the Etruscan region of Val d'Arno (Fig. 1A), the home of Dante, that yields a fauna of early Pleistocene age; for the second, another historic Etruscan locality, that of Monte Bamboli (Fig. 1B), with its remnants of late Miocene life; and for the third, the area north of Santa Fé, New Mexico (Fig. 1C), an earlier Miocene accumulation with deposits of Pleistocene age directly superposed.[1]

THE VAL D'ARNO PLEISTOCENE

In prehistoric Val d'Arno time, perhaps a half million years before the earliest civilization of which we have trace, ere the coming of the great cave-bear and contemporary races of men or of the mythological she-wolf of Rome, but long since these lands were raised from the shallow Eocene sea, what is now the valley of the river Arno seems to have been a region of plains, of forest vales, of shallow lakes, of lagoons, and of lignite-forming morasses. Today the morasses, preserved in the thick beds of unaltered tree trunks and forest débris underlying extensive areas of the recent surface, afford one of the chief industries of the region; for, tapped by many shafts, the ancient tree trunks are mined, corded, and burnt for coal. Buried amid this woodland growth, and in the adjoining clay and sand deposits of former lake bottoms, all deeply covered over by accumulations of more recent age, lie the fossilized remains of the creatures of Val d'Arno day. Through later change in the relative elevation of land and sea, that which was then a basin of deposition is now drained by the River Arno, which has cut the present broad valley into these accumulations of ancient time. It thus happens that the peasant repairing a deep rent of the swollen torrent or the miner working underground occasionally comes upon the limbs, jaw, or even skull of one of those creatures of long ago, and brings the trophy to his foreman or village mayor. Little by little the evidence has accumulated, an ever-lengthening list of forms. A few of these are almost indistinguishable from allied species now existing in Etrusca or near-by equatorial Africa, but the great majority are extinct—driven from their former home and off the earth by a complex of causes, among which may have predominated insect-born pestilence and the change of food and clime.

Would that we might see this great host on parade, pair by pair, the female and the male, as a Florentine artist quaintly depicts the cargo of the Ark; that we might check our hypotheses regarding their vanished bodies, muscular adaptations, coloration, and the story of their lives! Mastodons and mammoths, tapirs and boars, lions and sabre-toothed cats, long- and short-faced bears and wolves, in dying, have left their remains mingled here in the old lignite bogs, much as their distant cousins have left theirs trapped in the

[1]Two strikingly different examples of Pliocene deposition, the period that lay between the Pleistocene and Miocene and which is unrepresented at these localities, are: (1) the flintlike ledges, Fig. 3, discovered by the writer, lying high upon the metamorphics of little Mount Eden in southern California (Frick, C., 1921, Univ. Cal. Pub. Dept. Geol., XII, p. 335); and (2) the Coralline Crags of the British Coast, whose fossil-bearing beds occur at the base of cliffs submerged beneath the sea, save at low tide (see Moir, J. R., NATURAL HISTORY, XXIV, p. 640). In the flintlike Pliocene strata at Eden, California, there occurs a fauna exhibiting an interesting admixture of forms now extinct and of forms highly suggestive of animals surviving today. This is exampled in a species of extinct pony of typical Pliocene character (*Pliohippus edensis*) and its more horselike associate (*Pliohippus osborni*) which much resembles the typical horse of the overlying Pleistocene deposits; and is further exampled in the huge, extinct Pliocene cousin of *Hemicyon* (*Hyænarctos gregori*) and its modern-appearing, bearlike contemporary, *Plionarctus edensis*.

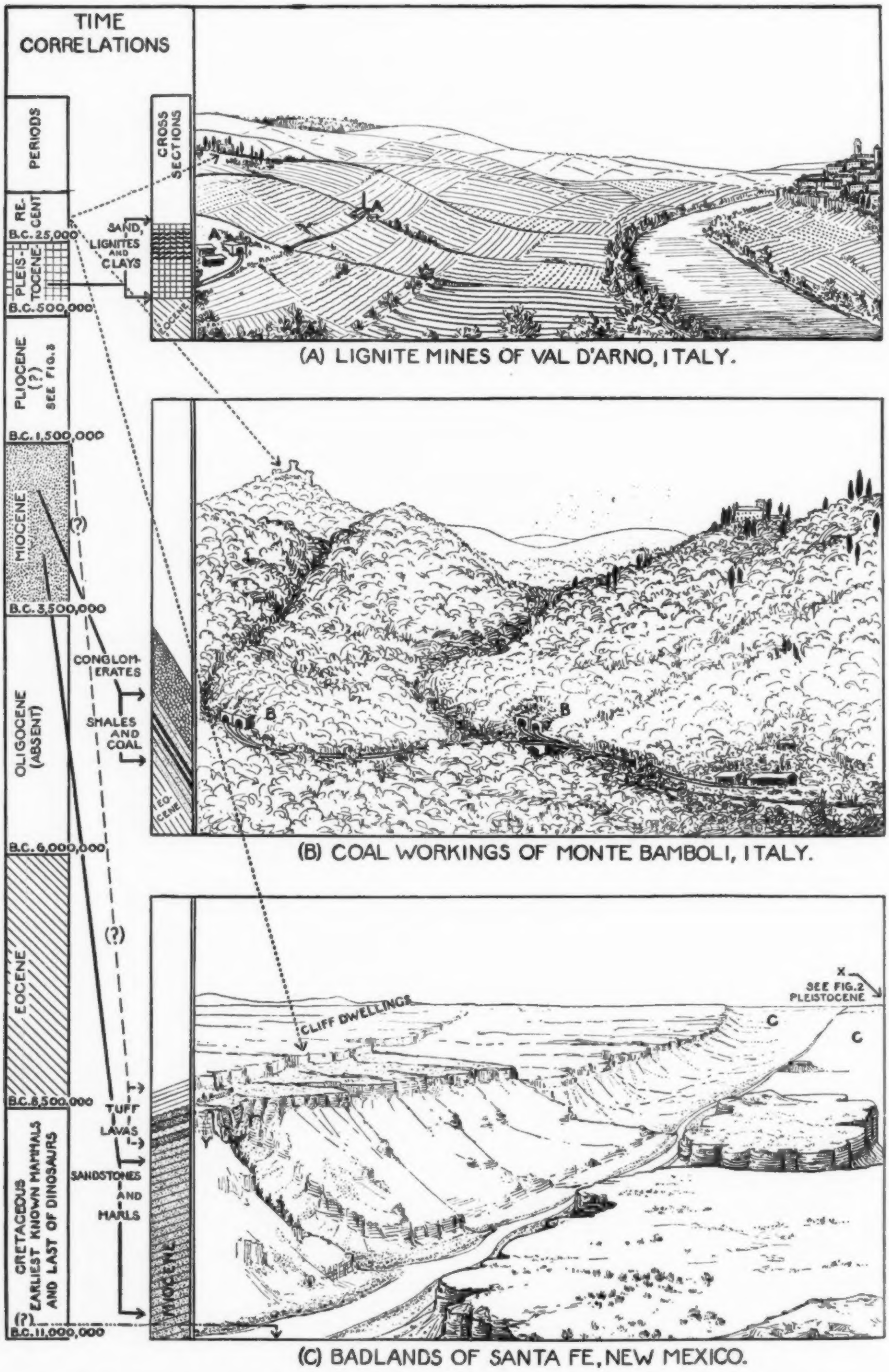


FIG. 1. THREE OF THE MANY DIFFERENT WAYS IN WHICH STRATA WITH FOSSILS OCCUR

A.—Pleistocene fauna buried in thick lignitic accumulation.
B.—Late Miocene remains embedded in thin coal seams.
C.—Mid-Miocene forms weathering out of open bad lands. Miocene deposits (C) overlain at "X" (see also Fig. 2) by a Pleistocene deposit (see Fig. 3 for an example of absent Pliocene), and overlain at "Y" by volcanic lava and ash—the latter the site of famous cliff dwellings.
Time scale adapted after Osborn and others. Compare Lucretia P. Osborn, 1925, "Chain of Life," Chart A, page 16, and table opposite page 84.

California tar pools of La Brea.[1] While the camel and great ground-sloths of the pools were absent, the single species of bison, of antelope, and of deer, of the tar pools, were here multiplied into numerous races of wild oxen, antelope, and noble, antlered stags, marvelous trophies for any baronial wall! Similarly the typical horse of La Brea, much resembling our modern friend, was replaced in the Val d'Arno by two widely differing species. One of these was even more like "Dobbin" than he of La Brea; the other (*E. stenonis*), though of equal stature, had teeth of more primitive form. Here, too, were huge rhinoceroses and hippopotami, hyænas, and baboons that are all unknown in the California pools! As for man himself, actual evidence of his presence with either fauna is as yet insufficient.[2] If present, his different habits and relatively small numbers might well preclude the ready finding of his remains.

THE MONTE BAMBOLI LATE MIOCENE

For a second and far different example of fossil occurrence let us search out the Late Miocene of Monte Bamboli a hundred kilometers to the south of Florence in the vicinity of Massa Maritima. We find ourselves in a rugged land where precipitous heights are crowned by walled towns with ruined towers that give occasional glimpses of the sea, where terraced hill and quiet valley are bound by wild and cedar-studded gorge; a region on which great earth forces have left their imprint in contorted strata and steaming boracic springs. Here, in thin seams of coal outcropping in the deeper brush-grown ravines, occur the scant remains of a fauna that flourished hundreds of thousands of years before that of post-Pliocene Val d'Arno—a million years before the building of Massa's now-crumbled baronial towers. These now thin and steeply pitching outcroppings, before they were buried by the accumulation of untold layers of bowlders and gravels, sands and clays, and compressed to coal by the titanic force of earth movement, were lignitic-forming bogs like those of later Val d'Arno time. Continental subsidence, subsequent to, and perhaps partially concomitant with the accumulation of the same deposits, turned this region into an island archipelago long previous to that gradual reëlevation which, resulting in deep erosion and the present mountainous topography, brought to light in narrow seams the compressed cross-sections of what were formerly open bogs.

The embedded bones of the ancient inhabitants are black-stained and often crushed beyond recognition. Fragments of skulls and jaws of swine and apes, of crocodiles and tortoises predominate. In fact they and certain remains of two species of antelope and of a peculiar hemicyonid (see p. 446), unless we include the teeth of a species of pony and tapir from similar coal seams of a near-by and possibly coeval marine accumulation, are the sole witnesses of an otherwise unknown phase of late Miocene life. These priceless remains were all obtained during the sixties and eighties when the same carbonaceous streaks were worked for coal. Unfortunately for science, economic conditions have long since closed the mines. I have visited the fallen pit heads and wondered to

[1] For interesting reconstructions of La Brea animals see illustrated article by Professor Osborn, *loc. cit.* p. 440.

[2] Note H. E. Anthony's discovery of a human skull in apparent association with the remains of extinct Pleistocene horses, camels, mastodons, and ground-sloths in the Pleistocene deposits near Riobamba, Ecuador. Sullivan, L. R., and Hellman, Milo, "The Punin Calvarium" *Anthropological Papers* of Amer. Mus. Nat. Hist., XXIII, Pt. VII.

FIG. 2.—PLEISTOCENE AND MIOCENE DEPOSITS OF THE SANTA FÉ BASIN, NEW MEXICO

In the foreground a remnant of the once widespread Pleistocene lies on the deeply eroded Miocene surface. Mrs. Childs Frick and Messrs. Blick and Rak pointing to protruding toes of a large wolf (?*Canis dirus*) as found by writer (view taken at "X" of Fig. 1)

FIG. 3.—PLEISTOCENE AND PLIOCENE DEPOSITS AT EDEN, SOUTHERN CALIFORNIA

Far-flung Pleistocene directly underlain by deposits of Pliocene age which rest upon the ancient rocks of Mount Eden and outcrop about its north flank (see footnote p. 441)

what future age is reserved the knowledge of the secrets of this unique Monte Bamboli life buried far within.

Fortunate it is for our understanding of the Miocene that Nature is not always so secretive of her treasure, and permits us to read in certain localities the fuller written page of other phases. Such regions are those great uplands where the fossiliferous strata, instead of being hidden by a deep mantle of soil and vegetation, or buried in narrow seams far within the ground, lie naked at the surface, subject to the erosive action of heat and cold, of wind and rain. Prominent among these are the great bad-land and desert areas of our own West.

THE MIOCENE OF SANTA FÉ, NEW MEXICO

For our third and final example let us visit one such area, the four hundred-square-mile stretch of bad lands which occupies a depression lying 6000 feet above the sea between the Jemez and the Sangre del Cristo ranges to the north of Santa Fé, New Mexico. As in the case of our two former examples this area was once a basin of deposition, but perhaps more a region of water holes and parched wastes seasonally green with the rain, than of forests and dark *estancias*. Since those days it has been elevated by great earth movements, and because of its aridity and the absence of protecting vegetation, much of its once vast content has been carried away. Under the work of the winds, the frost, and the rain, long hidden secrets of the lowest levels are being opened to the eye of man. Trenched by winding myriads of upward-creeping, jagged-walled, and rapidly widening arroyos, the stratified deposits of former centuries season upon season are borne away, here in swirling clouds of dust and there by the turbid waters of the silent Rio Grande. Who knows but that elsewhere deposited as dust and silt upon decaying carcasses and in the lapse of time all deeply covered over, these same sediments, in their turn, may reveal to our descendants of eons hence these very remains entombed today? Beneath pink escarpments of parched and broken uplands, crowned with scattered greasewood, junipers, and piñon pine, stretch the low north- and south-running flats of the great river, and those of its sandy washes from east and west, verdant with the irrigated fields of Mexican villages and Indian pueblos: a picturesque land which on every hand breathes of romance, that settled by the padres many years previous to the coming of the "Mayflower," is rich in quaint Indian ceremonials, in Spanish-American tradition, and in archæological as well as palæontological remains. But of those who have for centuries passed along the Santa Fé trail—priest, soldier, trapper, "forty-niner," archæologist, and engineer—who has noted far and wide Nature now disgorging that which she has held buried since remote Miocene age? Not our stage-driver, who, blind to the fossilized fragments of the bones of real camels that lie about its very base, calls attention to an eroded sandstone butte situated a few miles beyond the city, and widely known as the "Camel." Sphinxlike it crouches by the wayside on a pedestal whose foundations antedate the far-famed Egyptian monument by a minimum of two million years; a freak of erosion carved from some long vanished cliff-bound plateau, the passing remnant of what was once one vast stratified deposit, as are all those far-flung variegated pinnacles, flat-

capped domes and buttressed ridges. Each bluff reveals the component strata—layer upon layer of high-piled Miocene deposits that suggest the flat-lying leaves of a volume viewed endwise, and that form the matrix for occasional petrified remnants of the life of former days. Here and there layers of flintlike hardness, acting as stays to erosion, protrude in prominent bands beyond their softer fellows as do the covers of a pile of books beyond the leaves. All are but so many pages upon pages of a venerable scrapbook—Nature's titanic volume on "The Miocene of Santa Fé."

From such strata we have already garnered the remains of a noble fauna. In variety it exceeds that which we have secured from a rich deposit of somewhat similar age in the Mojave Desert of southern California, and matches the classic horizons of Europe. The majority of the forms are of races non-ancestral and far removed from those more modern creatures found buried in the remnants of a once widespread Pleistocene deposit that here and there still cap the old eroded Miocene surface (Fig. 2). Certain of these forms are of genera common to the Miocene of both the western and eastern hemispheres, while others are found in one hemisphere alone. Amongst those known only from America, and occurring in particular abundance here, are the forementioned camels, a galaxy of lost races varying in stature from diminutive gazelle-like to huge giraffe-like forms; herds of many kinds of delicately horned merycodi, those peculiar antelopine-deer; flocks of four-toed ruminating hogs, "oreodons," and of peccaries; and bands of fleet ponies, dew-clawed and striped perhaps as brilliantly as the zebra—absent in the Miocene of the eastern hemisphere, they are there replaced by representatives of the true deer, antelope, swine, and apes, all absent here. Amid remains suggestive of the Miocene of Europe and in instances of surviving genera of today we have found narrow- and broad-nosed rhinoceroses, a tiny deer *Blastomeryx*, hedgehogs, porcupine-like and peculiarly-horned rodents, primitive hares, gophers, squirrels, and mice; lizards and tortoises; lion- and lynx-like cats; weasels; foxes and coyotes, and heavy-headed wolves. Lastly, we have retrieved splendid skulls and jaws of other and stranger forms that, common to the Miocene of both continents, have since vanished into the medley of the great beyond—huge-bodied, prognostic-chinned mastodons, *Trilophodons*[1] (see foresketch); stout-limbed, three-toed hypohippine ponies that externally may have resembled the tapir almost as much as they resembled the horse; and the rare *Hemicyon*.[2]

It was the hope of finding remains of this so-called "half-dog" that really first brought us to Santa Fé. For seasons past we had been collecting in the above-mentioned Barstow Miocene of the Mojave Desert of California,[3] a task bequeathed me by my friends of the department of palæontology and historical geology of the University of California, who years before had located and made preliminary investigation of these difficult beds. One day I was surprised to discover among other interesting material forwarded from this area by my industrious field assistant, Mr. Joseph Rak, some teeth of the *Hemicyon* above mentioned, a

[1]Nobis, "Tooth Sequence in Certain Trilophodont Tetrabelodont Mastodons." Bull. Amer. Mus., LVI, Art. II, 1926.

[2]Nobis, "The Hemicyoninæ and an American Tertiary Bear." Bull. Amer. Mus., LVI, Art. 1, 1926.

[3]Merriam, J. C., 1919, Univ. Cal. Pub. Dept. Geol., XI, p. 438.

much-discussed, but little-known carnivorous genus of the French Miocene, related perhaps to the peculiar carnivore of Monte Bamboli (see p. 443) and to certain of the huge and inaptly named "hyæna-bears" of the later Pliocene, but heretofore unrecognized in America. Subsequently I happened to note the strong resemblance of a fragmentary lower jaw in the National Museum collection to certain of this new California material, and later was able definitely to determine it, too, as *Hemicyon*. This specimen had been found by Cope, then vertebrate palæontologist of the U. S. Geological Survey, in the vicinity of Santa Fé, a locality that had lain untouched by fossil hunters since his visit in 1874. Was material still to be found there? Might the old locality yield more of *Hemicyon*? Late in the summer of 1924 Messrs. Simpson and Falkenbach of an American Museum field party, en route home from Texas, were wired to stop over at Santa Fé. The first days' exploration brought fragmentary material, and the fourth a disintegrating block which they reported as containing the skull and jaws and parts of the skeleton of a great dog. Months later this block was received and opened up at the Museum. Before us lay a nearly complete skeleton of *Hemicyon*, revealing a beast with somewhat tiger-like proportions and doglike teeth, till lately quite unknown excepting for the few partial jaws and palates from the Mid-Miocene of France. Since then we have worked for many months at Santa Fé, and have secured a splendid series of remains representative of this ancient fauna, but to date, this first great trophy is our most complete specimen of any of those ancient animals, and, save for two fragmentary teeth, our only example of *Hemicyon*.

Among the finest specimens of last season was that found on a Sunday afternoon only a few hours before departing for the East. My wife and two of our little girls had motored out with me to an area that I had long wanted to examine. We had lunched in the scant shade of a small clump of junipers and started up the adjoining hillside for the view of what lay beyond, when suddenly and almost at the same instant we all four noticed scattered fragments of bone. These we traced on up the sandy slope, striking with our picks here and there in the soft débris-littered surface till we came upon their source. Immediately we were all engaged in scraping and brushing aside the soil and treating what lay beneath with thin shellac. Nor did we desist until the fast-lengthening shadows bade us hasten homeward. We had outlined the skull and the limb bones of a large rhinoceros. Hours of work still remained for our stronger, if not more expert successors, before the rocky area containing the bones could be quarried into solid blocks, bound with strips of plaster-soaked burlap, and crated for the eastward journey.

Some months before, marooned one evening by the unwonted collapse of our car high on the tuffs of the wooded Parajito plateau, sixty miles by winding mountainous road to the west of the "Camel," we were forced to spend the night in a little cabin deep within the neighboring Cañon of El Rito de los Frijoles. The reader may recall that this gorge contains some of the most impressive remains of prepueblan people, and is now the Bandelier National Monument. The storied dwellings of the ancient occupants lie partly against and partly within natural excavations in the tuff of the north

wall, and represent a civilization the zenith of which some archæologists place as early as 500 A.D.[1]

Turning our backs on ceremonial cave, ancient homes, and trails worn deep into the rock by moccasined feet of prehistoric men—let us follow the small creek, to which the Indian women of old must have repaired for daily household needs, through alders and tall bull pines to the mouth of the little cañon two miles distant. There, amid towering walls of stratified and superincumbent igneous rock, in view of the waterfalls by which El Rito plunges far below into the great White Rock Cañon of the Rio Grande, let us tarry to gaze upon the deep-bedded series of thin-edged layers of sands and clays, their capping of darker bands of lava, and the superincumbent gray wall of ash where the cliff dweller once made his home,—a vast accumulation representing a fraction of that gulf of time, estimated at from two to twenty million years, which separates yonder high abodes of ancient men from the fossilized remains of the mammals found buried in the lowest of those deep-laid clays.[2] Consider the centuries of accumulation represented in all these wide-stretching variegated sediments of the Santa Fé basin, hundreds on hundreds of feet of individual layer upon layer of paper-like shales, fine sandstones, intercalated fossiliferous clays, grits, and cobbles; the erosional interval of unrecorded duration that divides the higher of the sedimentary strata from the dark overlying beds of once molten lava and five hundred feet of gray tuffs; the succeeding years of upheaval and deformation that shattered the former continuity of all these layers and brought the Rocky Mountains into being; the ages necessary for the subsequent cutting of the White Rock Cañon gorge, for the slow reduction by wind and rain of these once vast Miocene deposits to their present remnants, and the preparation of the superincumbent Frijoles cañon to the needs of prehistoric men.

Such are but three of many examples that might be given of the ways in which remains of ancient life, long and deeply buried, are being brought to the light of day. We can but hope that Nature even now holds preserved, hidden away amid the earth's yet unexplored mile on mile of similar sedimentary strata, that longed-for evidence which will crown the coördinated research of some not too distant day and tell of earlier races of human beings—the precursors of such as these cliff dwellers, of their forebears of Val d'Arno and La Brea time, and of their and our direct ancestors of thousands of centuries before, the man-endowed contemporaries of the highly developed beasts of the Miocene of Monte Bamboli and of Santa Fé.

[1]Henderson, Junius, and W. W. Robbins, Bull. 54, Bureau Amer. Ethn., 1913, p. 54.

[2]Northeastward the "marls" are found lying directly upon the metamorphics outcropping in the foothills of the Sangre del Cristo range; northwestward they are separated by sediments of yet unknown age from the red beds of Triassic time; southward they may be in places directly underlaid by parts of the Cretaceous series

Early Days of Fossil Hunting in the High Plains

By W. D. MATTHEW

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THE HIGH PLAINS: that is the country that stretches west from the cultivated prairie to the foothills of the Rockies,—a broad level plain covered mostly with buffalo grass and other short grasses, suited for cattle raising and generally used that way, although every here and there one finds an optimistic "nester" or "Kincaider" who has fenced in a homestead and is trying to make a living from it.

This plain stretches from South Dakota to Texas, but the highest and the most typical portion of it lies east of Denver in eastern Colorado and western Kansas. Many rivers traverse it from west to east, running in broad, shallow, flat-bottomed valleys, flanked usually by a line of scarped cliffs, cut in the soft rocks that underlie the plains. These escarpments are carved by wind and weather into strange, irregular, and often fantastic outlines, and broaden out here and there into a maze of gullies and cañons most appropriately called *mauvaises terres*—bad lands—by the early explorers and settlers, for they are bare of vegetation, difficult to traverse whether on horse or on foot. Their maze of winding, waterless gullies form a trap for the inexperienced, either man or animal. There is little or no feed to attract the cattleman or sheep-herder, no chance of finding valuable mineral deposits to lure the prospector to these bad lands. There is just one valuable crop to be obtained there—fossils. They are the happy hunting grounds for the "bone-digger."

In the early days of the West, the "breaks" and bad lands served as a refuge and lurking ground for hostile Indians, and later for cattle rustlers and bandits. Today they are peaceable enough, where still wild and unsettled; their picturesque beauty and fantastic marvels of sculptured rock and cliff make them a place of pilgrimage for visitors. Many of the more remarkable and historic buttes and, cañons, landmarks on the early trails, have been set aside and protected as national monuments or state or local parks, and are visited by thousands of tourists.

The earliest fossils from the Plains were brought in by fur traders from St. Louis, who penetrated as far as the big bad lands of the Cheyenne River, and brought back fossil teeth and bones and battered skulls as evidence of their story of the great cemetery of strange beasts. These were studied and described by Joseph Leidy in 1847–55. Then came the preliminary reconnoissances for the transcontinental railways, and larger parties, usually protected by military escorts, traveled and mapped the various routes and reported upon their topography, geology, and economic possibilities, and incidentally made a more or less systematic search for fossils. This opened up a most promising new field for scientific discovery, and two able young scientists, Cope of Philadelphia and Marsh of New Haven, devoted their energy and resources to its exploration with a success that drew the attention of the whole scientific world, and inspired a large school of American palæontolo-

SLAB FROM EAST BUTTE, AGATE SPRINGS, MIOCENE BEDS, NEBRASKA

This block ($5\frac{1}{2}' \times 8'$) contains 21 skulls and parts of skeletons of *Diceratherium*, and is a section of the bone deposit or mass that extended through the east butte, Cook's ranch, Harrison County, Nebraska

gists. The sharp personal rivalry between these two men, while it had some unpleasant features, served to spur both to their utmost effort and hastened the development of method and technique in collecting as well as the publication of results.

The building of the transcontinental railroads made the western bad lands accessible for small collecting parties. Indians had ceased to be a danger, and a group of expert fossil hunters, among whom Hatcher, Wortman, and Sternberg were leaders, developed the rather simple technique of collecting and practical handling of a field party to fit the conditions of the western field.

The necessary equipment could be purchased at any considerable trading center. A team and wagon, a couple of saddle horses, tents, camp stove, etc., were the chief necessary equipment; each man's personal baggage and bedding roll were usually brought from home. The latter consisted of camping blankets and "tarp,"—a canvas sheet 6×16 feet of heavy duck, which, when properly folded, protected against anything short of a flood. A newcomer often brought a sleeping bag instead of the regular tarp. With provisions for the party and a few bags of oats for the horses, the outfit would pull out for the bad lands, and camp at some point where water and grass were at hand. Sometimes this was near a ranch house or homestead, more often not, for the important point was to get as far into the bad lands as practicable.

The day's work consisted in "looking out" as much as one could cover of the rock formation exposed in cañons and gullies, prowling over the weathered slopes, and climbing along the steeper cliffs, watching always for the peculiar colors and forms of weathered bone fragments, following up every trail of fragments to its source, and prospecting cautiously with a light pick or digging chisel to see what, if anything, is left in the rock. Such a prospect came often as a blessed relief after hours of climbing and scrambling had reduced one to a state of staggering weariness. If it was a valuable find, it might mean some hours or days of work to prospect and collect. More often, of course, it was a minor find, a jaw or a few bones, and still more frequently nothing worth while would be there. Even at that it was an excuse for a little rest, and one could go on hopefully, praying for better luck next time. Toward sunset one must get back to camp, tired and discouraged by an unsuccessful day, or comparatively fresh and cheerful with a new discovery to report. Perhaps it might be a complete skull or a skeleton of some rare or imperfectly known fossil; perhaps some species altogether new to science,—in any case a prize that paid for much weariness and many disappointments. Then supper, a pipe, and to bed, and the same routine repeated the next day and the next, until all the bad lands within practical reach of the camp—five miles on foot, ten with the help of saddle horses—have been prospected, and another camping site must be found. There the same order of work is repeated, and so on until the season closes or the bad lands area has all been "looked out." By the end of the season a very considerable collection has accumulated, and one realizes with some surprise that what seemed desperately poor pickings has after all yielded an important collection.

Of the technique of collecting and preparing fossils, I need say nothing here; that has been fully explained in other numbers of NATURAL HISTORY.

Bone Cabin Quarry, Wyoming, with camp in background. In the group of workers are Messrs. Lull, Granger, Schneider, and Kaisen

Camp at Hell Basin, Washakie bad lands, Wyoming

Wasatch bad lands near Otto, Wyoming.—This *Coryphodon* skull had entirely weathered out into small fragments. The earth was swept up and carried seven miles to a stream, washed and sieved, and then pieced together in the Museum, forming a complete skull and jaws. The two men are Messrs. Riggs and Brown

Hypohippus skeleton in rock (Miocene-Lower Pliocene). Davis ranch near Grover, Colorado

Stratigraphic studies and exact records of geological level were developed in the nineties, and added a new and fascinating interest to the work, as one could actually trace in the succession of strata the progressive evolution of the different races, verifying in specimen after specimen the primitive characters of those from the lower layers, the progressive character of those from the upper layers, and the intermediate conditions in specimens from the middle beds. No one carries a more solid conviction of the truth of evolution than the field palæontologist. He has seen it with his own eyes, and it is quite useless for learned pundits of the pulpit or the laboratory to tell *him* that evolution is only a hypothesis, or that palæontology does not prove anything about it. He knows better; he has seen it himself ineffaceably inscribed in the records of the past.

The coming of the automobile has revolutionized the fossil-hunting business. For one thing, it has greatly widened the range of practical field work. The old conditions limited it to a radius of five or ten miles from water and feed. A "dry camp" supplied at intervals with food and water might carry the exploration a stage further, but throughout the West, especially between the Rockies and the Sierras, there were enormous areas of bad-land exposures that it was not practicable to prospect adequately for lack of water or feed. With the automobile there is probably no promising exposure so distant but that it can be, and will be prospected for fossils. Moreover, the range of a day's collecting with an automobile is so greatly increased, that most areas in the Plains can be prospected from some near-by settlement, and it hardly pays even to camp out. The old days of the open range have passed; much of the country is fenced up and a good part of it homesteaded, and the residents no longer welcome strangers with the old unquestioning cordial greeting. The bad lands of the Plains, the old hunting grounds of the bone-digger, are not exhausted of their fossils. They never will be, for storms and weathering expose an ever renewed supply. But some of the joys of discovery have passed; the new fossils are apt to be like those previously known. And the collecting methods are a bit more prosaic. The old delightful camping routine, with its pioneer equipment and unhindered freedom of exploration, has shifted and changed to automobile travel in the deserts and plateaus of the Great Basin and intermontane states, a field for discovery which will take many years to cover. The high plains, too, will always be a great fossil field, but the romance of their discovery and exploration by the early fossil hunters belongs to the past.

Early Fossil Hunting in the Rocky Mountains

By RICHARD SWANN LULL
Professor of Palæontology, Yale University; Director, Peabody Museum

IT was in 1868 that the pioneer among American palæontologists, Othniel Charles Marsh, made his first trip to the Rocky Mountains for fossils, a trip that was to stimulate a life-long interest in these relics of the past, one ultimate result of which was the amassing of the great collections at Yale. Of all the material Marsh assembled, none made a greater appeal, both to himself and the public imagination, than did the horses among mammals and the dinosaurs among reptiles, representatives of which he found on this initial trip. The Peabody Museum still treasures the original horse specimen, *Protohippus parvulus*, which Professor Marsh found in western Nebraska, but the identity of the dinosaur bone which he discovered has been lost sight of in the passage of time. The year 1870 saw the inauguration of the first formal expedition from Yale, followed by others in the succeeding years until 1873, after which the work was conducted in another way. The personnel of these early expeditions was made up of Yale men, seniors or recent graduates, who paid their own way, giving their services for the sake of the thrill of big-game hunting, both living and extinct, and the adventure of exploration in unknown fields. Marsh had keen insight in his choice of men, for, while few of the members of his parties became professional palæontologists, they, almost without exception, had worthy careers in other walks of life, two, at least, becoming members of the Yale Corporation and several becoming members of her faculties.

On the material side these expeditions were remarkably successful, especially when one remembers that the vicissitudes encountered were not entirely those of the physical environment. Tons of specimens were brought in, collected from a virgin field and revealing at almost every turn discoveries new to science; species, genera, and new orders of creatures, the very existence of which had been beyond imagination. One only wishes that the methods of collecting had been more refined, but the present technique had not yet been developed, and the extreme value of the specimens compensates for shortcomings of original attainment.

After 1873 the student expeditions ceased, although they had done yeoman service in Kansas, Nebraska, and Wyoming, and from Colorado to Oregon. This was due in part to increasing Indian difficulties and in part, we imagine, to Professor Marsh's desire to collect more intensively in certain regions or horizons, as he was beginning to amass material for his projected monographs on dinosaurs, horses, titanotheres, Odontornithes, and others. To this end he had paid collectors, some of whom had served the earlier expeditions as cook, horse wrangler, or guide, and not only knew the country but had of necessity learned something of the rather crude technique of that day.

Other young men who were regularly connected with the Museum were also sent into the field, and some of these, notably S. W. Williston and J. B. Hatcher, were not only highly produc-

tive of material for the Yale Museum, but became, subsequently, men of outstanding rank among palæontological workers. Williston's name is found attached to numerous specimens, principally from the Niobrara Cretaceous, toothed birds, pterodactyls, and marine saurians, while we always think of Hatcher in connection with the Ceratopsia skulls, of which upward of two score were collected largely by himself and Peterson, now of the Carnegie Museum. With Professor Beecher they also gathered the large amount of Lance mammal material seen in the Museum at Yale and the National Museum. Hatcher spent portions of the years from 1886 to 1888 in the field, during which he collected 105 nearly complete titanothere skulls and much associated material.

It must be remembered that this collecting was financed largely by Professor Marsh himself up to the time of his appointment as Vertebrate Palæontologist to the United States Geological Survey, July 1, 1882. From that time on until Marsh's death in 1899 Government assistance was generally available. Material was therefore collected and paid for jointly by Marsh and the United States and, after the professor's death, was divided between the Peabody and the National museums, constituting the so-called Marsh Collection of each institution, for in 1896 the entire share of the Yale professor was deeded to Yale University to be cherished forever.

Midday meal.—Expedition of 1870

Upon the coming of the present incumbent of the Chair of Palæontology twenty years ago, there was a vast and important collection at Yale, second only in extent to that of the American Museum and containing items which are unique and priceless in their importance to science, the fruition of a third of a century of intensive work. There were and are certain important gaps in the series to be filled. Hence it seemed wise to revive the field work, and four expeditions were undertaken

Collecting fossils in the Rocky Mountains, 1871

from 1908 to 1915, when the coming of the war made such matters relatively unimportant. The passing of the old Museum building in 1917 and the lean years which followed up to the dedication of the new edifice were perhaps reasons sufficient for non-activity in the field.

The old-time expeditions were staged in the real West, at a time when lack of means of transportation and the presence of Indian menace, together with the very intimate contact every fossil hunter must have with his physical surroundings—with fatigue, heat and cold, hunger and thirst—made the search for the prehistoric a real adventure suited to red-blooded men. Big game was then abundant, but this good was offset by days of labor through rolling sandhills, with infrequent streams, often alkaline, little vegetation, and the menace of occasional prairie fire and Indian attack, in spite of which material by the ton was collected with unflagging zeal.

One of Williston's letters to Marsh (June 1, 1876) tells how the party narrowly escaped death from water while in Kansas. "The Smoky Hill rose nearly twenty feet in about as many minutes, catching us asleep at half past two in the morning and drowning one of our horses. We swam and waded ashore as we jumped from our beds, but succeeded in saving most of our camp outfit which drifted ashore." This is merely one of the vicissitudes of these romantic days, most of which are unrecorded except in the memories of a dwindling group of men.

Personnel of the 1872 Expedition—Marsh standing in center

Williston tells us much about the early dinosaur collecting—how Professor Arthur Lakes discovered in March, 1877, near Morrison, Colorado, the dinosaur which was to be the type *Atlantosaurus immanis*, now preserved at Yale.

Arthur Lakes carried on explorations with William Reed and independently for some years, and a number of important specimens in the Peabody Museum collection bear his name. He also made sketches in water color of the various localities and the old-time methods of exhumation, several of which, bearing the date of 1879, are now hanging in the palæontological laboratory at Yale. The value of these is at once evident, for in the days before the omnipresent kodak, when the "wet plate" process of photography limited its use in the field, sketching was the only method of recording pictorially such events as these.

The year 1877 was highly productive of discovery, for Lakes was followed by O. W. Lucas, who found material near Garden City, Colorado, which he in turn reported to Cope. This was the *Camarasaurus supremus* type now in the American Museum of Natural History. While a veteran collector, David Baldwin, who had previously worked in New Mexico, found the unique and still somewhat problematical *Hallopus* specimen at Canyon City.

Como Bluff in central Wyoming, which became amazingly productive, was also discovered as a dinosaur locality in 1877. This time the collector was William, commonly known as "Bill," Reed, formerly a professional game hunter, who supplied certain of the construction camps of the Union Pacific Railroad with meat, as did the more renowned Buffalo Bill. Upon the announcement of this discovery, Williston was sent out and shortly

opened Quarry No. 1 of a long series of excavations along the face of the eroded anticline which forms the bluffs. Among the most important of Reed's finds was the famous type of *Brontosaurus excelsus*, shortly to be mounted in the Great Hall of the new Peabody Museum, a specimen known the world over but, except for the pelvis and hind limbs, never articulated. After some fifty years it will come into its own!

Professor Mudge, of the University of Kansas, together with Messrs. Felch and Williston, opened the quarry which contained the type of *Diplodocus*. As Williston says, "it consisted of hind leg, pelvis, and much of the tail, lying in very orderly arrangement in the sandstone near the edge of the quarry," but the bones were broken into innumerable pieces and "most of them went into the dump." This is of course greatly to be deplored, but two circumstances conspired to produce the result. The technique of today had not been invented which makes the saving of much poorer material than this a matter of relative ease. The other factor was the apparent need of haste, as the collectors were urged to get their material to New Haven with the utmost dispatch, such was the rivalry of the already opposing palæontological camps.

These collectors, led largely by Reed, worked the year round, defying alike the summer heat and the winter cold, the thermometer once falling 38° below zero with high winds and snow. Every possible day saw them actually in the quarries or prospecting for more, while utterly impossible weather only shifted their activities to other work, such as the search of "pay dirt" for tiny mammal and other remains. Nor were the summer's days entirely uneventful, for once they were visited by swarms of siredons (salamanders) which, as Lakes says, "so insinuated themselves under every box and bed that although we threw out and killed dozens, it became useless to stop the horde . . . that waddled leisurely into the tents, as if they had a perfect right to them. . . . What with the noise of the creatures . . . and the baying of wild geese on the lake, the gnawing of mice at our furniture, and the roar of the thunder, the voices of the night were not conducive to slumber."

Another amazing locality, the famous Bone Cabin Quarry, lies at the head of a draw, tributary to the Little Medicine Bow River and not many miles west of Como Bluff. Here a Mexican sheep-herder had built the foundations of his hut of weathered-out dinosaur bones, the centra of vertebræ and pieces of vast limb bones. It was in 1898 that Walter Granger saw and realized the significance of this remarkable building and began, together with Doctor Wortman, the excavation of this world-famous quarry. Hither the following year came Doctor Matthew, and the author of this paper joined Mr. Granger's party in the work of excavation,—his initiation into the science of palæontology. The dinosaur layer at Bone Cabin is part of the same deposit as that at Como Bluff, the apparent discontinuity being the result of tremendous folding and subsequent erosion, two factors which bring to light material which otherwise would be buried far beneath the surface of the earth. At Como approximately complete skeletons may be had, while at Bone Cabin there are members rather than skeletons, tails, limbs, necks, the result of burial of disintegrating carcasses in some ancient backwater or river bar.

The Expedition of 1873 in the Bridger Beds

The product of a number of years of labor has been remarkable, representing at least seventy-three dinosaurs large and small. Osborn estimates the grand total, counting those eroded away, as at least a hundred. The principal reason for discontinuing the work was not that the quarry had ceased to yield, but that the bone-bearing strata were dipping too deep below the surface for economy of labor.

Sheep Creek, not very far from Bone Cabin, produced the splendid *Diplodocus* specimen of the Carnegie Museum, found by Doctor Wortman in 1899. Jacob Wortman, himself a research man of distinction, collected originally for Professor Cope and later for the American Museum and the Carnegie Museum of Pittsburgh. It is to him, I believe, that we owe the perfection of our modern methods of collection with the plaster and burlap bandages and splints, the application of a well-known surgical method by one who was himself a physician, and which not only makes possible the securing of relatively imperfect material, but adds greatly to the ease of subsequent restoration.

But not all of the old-time collecting was of dinosaurs, and the recognition of some of the Tertiary deposits, notably the Oligocene of the Big Bad Lands of South Dakota, is worth the telling. It was in 1874, when the threat of Indian uprising made it unwise to continue the student expeditions, that Professor Marsh went west alone, relying on the frontiersmen, his former guides, for aid. The story is that an Indian brought in a tooth in his

tobacco pouch which he said was that of a "big horse struck by lightning." This Marsh recognized and named the *Brontotherium*, or thunder beast, a name apparently suggested by the Indian's remark.

Marsh was extremely anxious to penetrate into the new locality, but the Indians resented the coming of the white men into the Black Hills which were sacred to their forefathers. They could not appreciate a "bone hunt" and naturally imputed another motive, that of the search for gold, to the white men. General E. O. C. Ord, commanding the Department of the Platte, and Colonel T. H. Stanton, to whom Professor Marsh was first indebted for information concerning the newly-found fossil bed, promised every assistance toward its exploitation. The weather was already cold and the Indians feverishly sensitive about the approach of white men to the Black Hills, which had been given to them by treaty in 1868. Fortunately the fossil locality did not lie within the limits of any reservation, though it did lie north of the White River, where the Indians were less amenable to authority. There were camped in their tribal villages, within a radius of ten miles of the Agency, no fewer than 13,000 Indians. The Cheyennes were sulky because they had been ordered farther south; the Arapahoes were fresh from their fight and losses in the battle on Powder River with Lieutenant Bates; and in addition there were outlaws, renegade Indians, who made the vicinity of the Agency not only unquiet but actually dangerous.

The Indians finally consented to allow the expedition to proceed with an escort of young warriors under the leadership of the famous Sitting Bull, ostensibly to guard the party against the northern Indians, but really to keep watch upon the actions of the bone hunters. But snow fell, delaying the departure, and in the meanwhile the annuities were issued, so the Indians were no longer on their good behavior, and their sentiment toward the expedition again changed to one of distrust. When finally ready to start, so hostile a demonstration was made that their departure would probably have precipitated a general *mêlée*, and the only prudent thing to do was to withdraw.

Finally, exasperated by the numerous delays, Professor Marsh decided to evade the Indians, and that night, shortly after midnight, the expedition filed as silently as possible between the Indian villages to the only place where the White River could be forded. As they marched by, the Indians dogs barked furiously, but their owners slept. If the expedition had been attacked at this time, its case would have been indeed hopeless. Threats of attack by the northern Indians made the risk of remaining very great but, in spite of it, sufficient time had to be taken properly to pack the fossils, which would otherwise have been destroyed in transit. The party retreated, however, none too soon, as subsequent reports state that a large war party scoured the Bad Lands the following day in the vain search for the intrepid white "Bone Chief" and his band.

FIG. 1.—SOUTHERN GATEWAY TO THE ARBUCKLE MOUNTAINS, OKLAHOMA—THE WASHITA RIVER GORGE

The Arbuckle Mountains, Oklahoma

THE FOSSIL COLLECTOR'S HAPPY HUNTING GROUND

By CHESTER A. REEDS

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FOREWORD.—The writer's first experience as a collector in the Arbuckles was in 1903. Between that date and 1915, he traversed these mountains on five different occasions and made large collections of fossils for Oklahoma University, the United States Geological Survey, Yale University Museum, and the American Museum of Natural History.

INTRODUCTION

FEW are the places on the surface of the earth where, in walking a few miles, one can cross as many thousand feet of upturned and beveled-off strata as in the Arbuckle Mountains of Oklahoma. In addition to being wild and picturesque and full of Indian and cowboy lore, the region is a veritable paradise for the geological student. The stratigraphic succession of fossilferous beds ranges from the pre-Cambrian granite to the "Red Beds" of Permian age. Unlike the better-known section of Palæozoic rocks in New York State, the Arbuckle Mountain exposures, which belong to the same era of geologic time, are free of glacial drift and all other coverings.

The Arbuckle Mountain uplift is to be found in the south central part of Oklahoma in the counties of Murray, Carter, Pontotoc, and Johnston. Its area is roughly triangular in shape, having thirty-five miles on a side, with a handle-shaped portion, ten miles north-south by eighteen east-west, extending to the west across the Indian Meridian. The Washita River valley and gorge separate the two portions.

The term Arbuckle Mountains was derived from Fort Arbuckle, which was named for Brevet Brigadier General Matthew Arbuckle, who fought in the Mexican war of 1845. All lands in the former Chickasaw Nation, in fact all sections of what is now Oklahoma, except the panhandle strip north of Texas, were surveyed from a stone post, on the Indian Meridian, 97° 15′ W., which stood on the site of the fort. On the map, page 468, the "base line" of the Survey crosses the Indian Meridian at the stone post, and the township and range line readings on the map start from this bench mark. The fort was maintained by the Federal Government for many years, but has long since been abandoned. On the latest maps the name Arbuckle has been given to the post office, village, and rock-crusher in the Washita River gorge.

Prior to Oklahoma's being admitted to statehood in 1907, all the fine valley lands and considerable portions of the Arbuckle uplift had been allotted as homesteads by the Chickasaw and Choctaw Indians. Choice of 160 acres of first grade or larger amounts of second or third grade lands were allowed each member of an Indian family that possessed full or partial strains of Indian blood. Each former negro slave (freedman) of the Indians could select 40 acres. It is not surprising thus that much of the lowlands was cultivated while the remaining forested belts and rocky lands were devoted to grazing.

The grazed uplands, whether fenced or in open range, were a boon to the collector, for the cattle had cropped the grass close to the rocky surface, not only in places where the strata were gently inclined, but also in others where

Fig. 2—A typical view of the Arbuckle Mountain Plateau.—Looking southeast across the upturned Arbuckle limestone N.E. ¼, Sec. 21, T. 1 S., R. 1 E., five miles southwest of Davis, Oklahoma. The pre-Cambrian porphyry monadnock, of the East Timbered Hills, is in the background

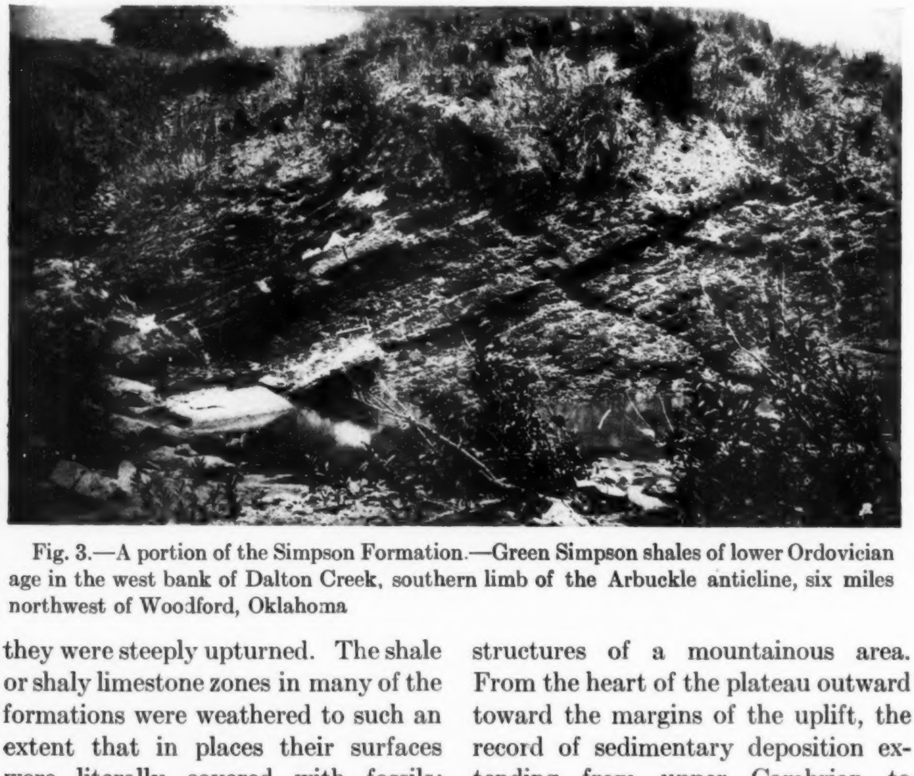

Fig. 3.—A portion of the Simpson Formation.—Green Simpson shales of lower Ordovician age in the west bank of Dalton Creek, southern limb of the Arbuckle anticline, six miles northwest of Woodford, Oklahoma

they were steeply upturned. The shale or shaly limestone zones in many of the formations were weathered to such an extent that in places their surfaces were literally covered with fossils; weathered specimens oftentimes protruded from the harder limestone ledges.

GENERAL FEATURES

The Arbuckles are not mountains in the sense that they are high above sea-level—for the highest point is only 1350 feet above tide, and the lowest, 750 feet; at present they form a dissected upland exhibiting the basal structures of a mountainous area. From the heart of the plateau outward toward the margins of the uplift, the record of sedimentary deposition extending from upper Cambrian to Pennsylvanian time is well exposed. The impending events that followed this long era of sedimentation are suggested by the extensive Franks conglomerate of Pennsylvanian age on the northwestern and northeastern sides of the area, the Permian "Red Beds" conglomerate across the west end, and the Cretaceous deposits across the southeastern side of the uplift.

About the middle of the Carboniferous period, the older sediments, which had remained practically flat during successive periods of deposition, were uplifted, folded and faulted, forming high mountains. This development of the Arbuckle uplift is similar to that of the Appalachian Mountains in the eastern part of the United States. The earth forces that folded the rocks in one place buckled up the horizontal beds in the other area; in fact, they may be different parts of the same mountain system, as the former State Geologist of Arkansas, Professor J. C. Branner, and some more recent geologists contend. During and following the uplift and before the end of Permian time, the thousands of feet of rock that comprised the tops of these mountains were eroded away, and the upturned edges of the ancient strata, including the pre-Cambrian granite and porphyry in the heart of the mountains, were laid bare. Land conditions evidently prevailed during the following Triassic and Jurassic periods.

In Cretaceous time, when the waters of the Gulf of Mexico joined with those of the Arctic throughout the High Plains area, the entire Arbuckle Mountain uplift was covered by the sea, and a basal formation consisting of beach and nearshore deposits was laid down horizontally on a nearly smooth floor composed of granite and upturned beds of limestone, shale and sandstone, of varying degrees of hardness.

Following the retreat of the Cretaceous sea, caused by the uplift of the Rocky Mountains and the High Plains region, the streams, which took courses across the sandy formation that covered the Arbuckle uplift, began rapidly to erode the cover from the plateau. As these soft rocks were removed toward the south, the large streams were imposed upon the hard rocks of the Arbuckle plateau. The streams near the eastern end of the uplift, from which the Cretaceous deposits were last removed, still retain their wide shallow valleys. The Washita River, however, flows on a lower plain before reaching and after its passage through its deep and meandering gorge across the Arbuckle Mountains. The soft rocks in its course were worn down more rapidly than the hard limestones in the adjacent areas, and it was only at the two-mile gorge that it had to exert its power.

Along the northeast and southwest margins of the Arbuckle plateau there is a descent of from 100 to 400 feet to the level of the plain formed on the softer Carboniferous rocks. The erosion which produced this plain is probably of Tertiary age. Since the formation of this plain, the Arbuckle plateau and the surrounding region have been tilted slightly toward the southeast, for the large streams have descended in the softer rocks to approximately 200 feet below the level of the Tertiary plain and have cut for themselves wide, flat valleys. The smaller tributary streams have steeper grades, particularly near their sources.

The minor topographic features of the Arbuckle plateau are due chiefly to the varying resistance of the formations to erosion since the removal of the Cretaceous rocks. This differential erosion has emphasized the structural elements of the plateau, for the broad truncated anticlines and domes rise higher than the narrow faulted synclines and basins, and the softer formations outcrop in timbered annular valleys while the harder limestone beds form prominent ridges and cuestas.

Fig. 4.—General view along the strike of a Viola limestone ridge. The Viola limestone of middle and upper Ordovician age is on edge in the northeast limb of the Arbuckle anticline, four miles south of Davis, Oklahoma. Simpson formation in timbered belt on left margin, Arbuckle limestone in background; in forested area to the right, Sylvan shale, Hunton beds, Woodford chert, and valley of the Washita River

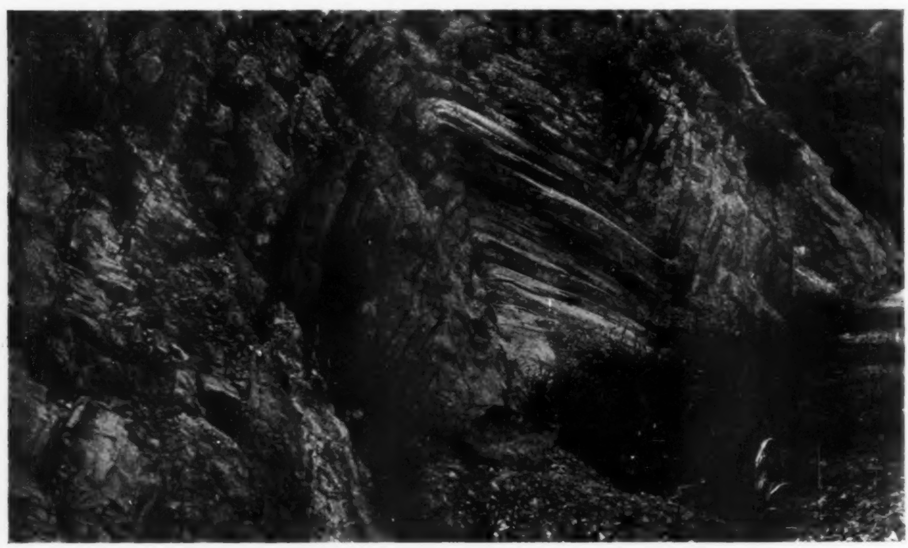

Fig. 5.—A minor fold in the structure of the Arbuckle Mountains. Elbow fold in Viola limestone, Dougherty anticline, Little Cañon of the Washita River, three miles south of Davis, Oklahoma

GEOLOGIC SECTIONS

From the beautiful Turner Falls on Honey Creek the Colbert porphyry of the East Timbered Hills rises to the triangulation station of the United States Geological Survey, the highest point in the Arbuckle uplift. A view from this station gives one a superb impression of the fossiliferous rocks of the region. Within a distance of five miles southward toward Springer, one may look across 12,150 feet of upturned strata which represent that long era of geologic time known as the Palæozoic. This remarkable section embraces the southern limb of the

broad Arbuckle anticline west of the Washita River with all the beds clearly exposed and not disturbed by faulting.

Within a distance of four miles to the eastward of the triangulation station one may see the section repeated in the northeast limb of the Arbuckle anticline. The beds in this limb are more steeply upturned than in the southern one; in fact, most of them are vertically disposed, except at the northern end, where two minor folds have been impressed on the larger structure, as noted on the accompanying geologic map.

The entire section is also well exposed in the gently pitching limb of the Tishomingo anticline extending from the Tishomingo granite in the vicinity of Mill Creek westward toward Dougherty on the Washita River. Various sections of the formations above the thick Arbuckle limestone may be seen to advantage in the eastwardly pitching limb of the Hunton anticline, northward from Bromide; in the Lawrence anticline in the northeast corner of the uplift; and in the smaller Dougherty anticline and Vine dome north of Dougherty.

The extent and major subdivisions of the rocks of the Arbuckle Mountains are shown on the map on page 468, while the minor subdivisions, thickness, position in the geologic time scale and their characteristic fossils are summarized in the table on page 470. In this connection other publications[1] dealing with the Arbuckle Mountains may be examined with profit.

[1] Taff, J. A., 1902, U. S. Geol. Surv., Atoka Folio, No. 79. Taff, J. A., 1903, U. S. Geol. Surv., Tishomingo Folio, No. 98. Taff, J. A., 1904, Preliminary Report on the Geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklohoma. U. S. Geol. Surv. Professional Paper, No. 31.
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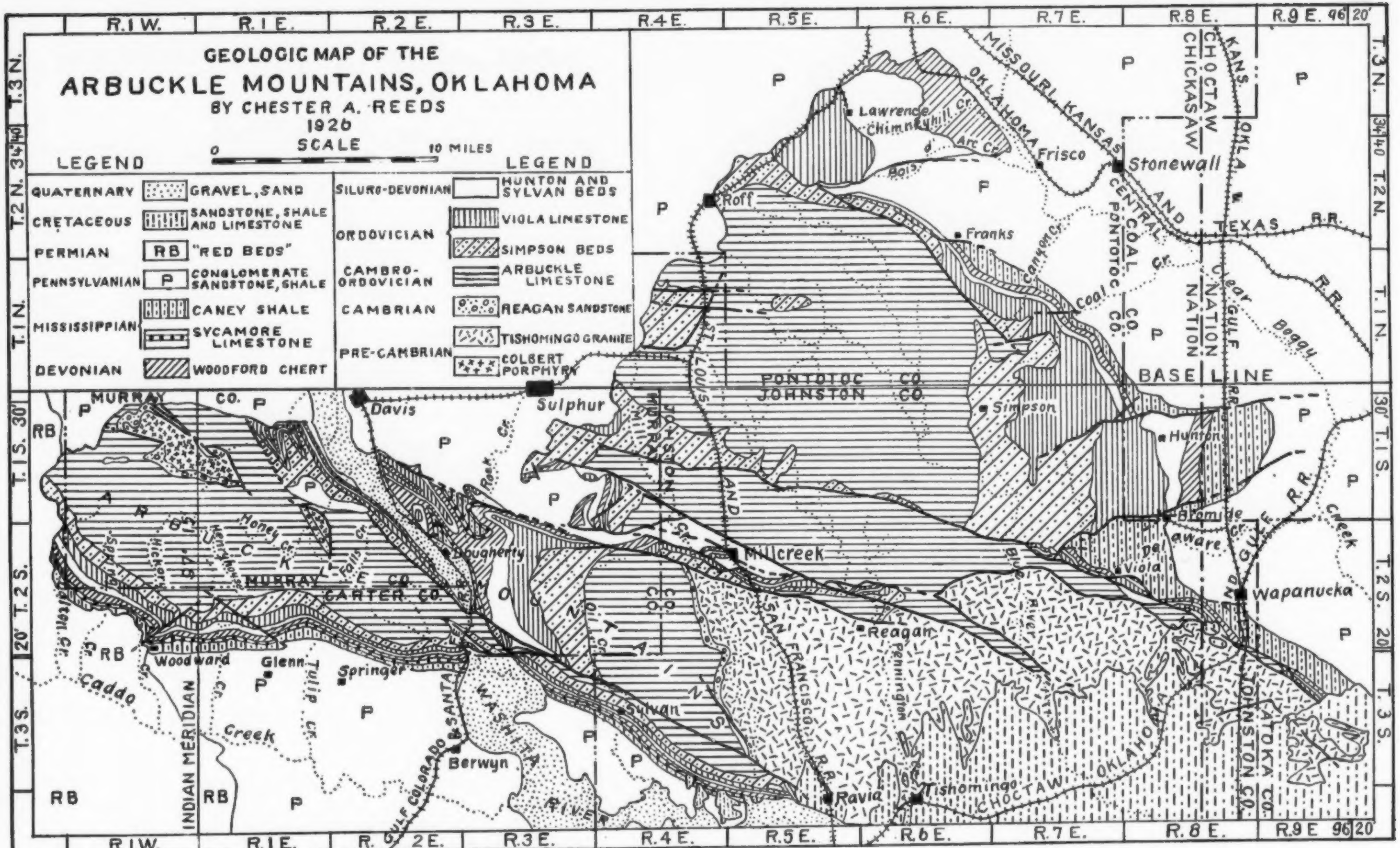
Reeds, C. A., 1911, The Hunton Formation of Oklahoma. Am. Jour. Sci., 4th ser., Vol. 32, pp. 256–268.
Goldston, W. L. Jr., 1922, Differentiation and Structure of the Glenn Formation. Am. Assoc. Petroleum Geologists, Bull., Vol. 6, pp. 5–23.
Morgan, Geo. D., 1924, Geology of the Stonewall Quadrangle, Okla. Bureau of Geology, Bull. 2.
Gould, Chas. N., 1925, Index to the Stratigraphy of Oklahoma with lists of Characteristic Fossils by C. E. Decker, Okla. Geol. Surv. Bull. No. 35.

SOME PERSONAL EXPERIENCES

A collector's life in the Arbuckle Mountains is full of thrills. You may be nonplussed when you ride forth on the country physician's horse and inquire the way of a farmer. The farmer looks at the horse and then at you, several times, and finally replies: "You are riding 'Old Baldy' today." When you explain to him that the doctor is ill and that you have permission to ride the horse, he is surprised, and you press your claim. He answers but is not satisfied, for horses have been stolen, and if you are not a "horse thief," what are you? Even at night, when it is too dark to see the way home and you depend upon the horse to keep the road, some chance passer-by will recognize your mount. This sense of recognition of things native seems uncanny.

When you look at your field map and inquire the way to the "Washboard Springs" on Dalton Creek, some individuals will volunteer to show you the way and incidently try to ferret out your business; others will ask "How do you do it?" while still others will spy on you from cover, for they all have the idea that you are looking for the "hidden treasure" that was buried there by the Dalton gang of outlaws, and that you have the maps showing its location.

You may perhaps find several hundred specimens of that rare ball-shaped echinoderm, known as *Camarocrinus* in the Haragan shale, and as you attempt to haul them away a full-blood Indian will ride upon the scene and say "If there is money in these rocks me want it." You tell him that they have no money value, that you are collecting them for a school, an



GEOLOGIC MAP OF THE ARBUCKLE MOUNTAINS, OKLAHOMA

Fig. 6.—This map embraces a number of new features not shown in the preliminary map by J. A. Taff, 1904, in Professional Paper No. 31, United States Geological Survey

academy. He begins to understand but is not satisfied. Your driver tells him that you are from the Great White Father and that you are taking the specimens with you and will acknowledge John Seeley, Indian from Coal Creek as donor of the specimens. He is satisfied and permits you to depart with your treasure.

You may be innocently breaking fossils out of the Hunton beds on Honey Creek, when a 300-pound man with a shotgun in his hand sternly calls out to you from the bluff above:

"What are yer doing there? Do yer think yer have got yer a gold mine?"

When you reply that you are breaking *Orthostrophia strophomenoides* out of the rock, he asks.

"What did yer say?"

You repeat, but still he does not seem to understand for he begins to feel his way down the cliff with gun in hand. You note then that a ten-foot stream and a seven-strand barbed wire fence, with a "no trespass" sign on it, intervene. Fortunately you are on the outside of the fence and you sit tight. He balances himself well on the foot-log and even climbs through the fence, with difficulty, but not a word until he stands alongside. Between the hurried gasps for breath he repeats "What did yer say?" Then again you tell him that you are breaking *Orthostrophia strophomenoides* out of the rock. He appears a bit disturbed, but when you hand one of the small brachiopod shells to him he replies, "Oh, I didn't know they were there" and adds "I was really only looking for a chicken hawk."

You will tremble from head to foot for an instant when the rattlesnake, that gentlemanly denizen of the prairies and woods, suddenly gives you that shrill, hair-raising warning of an untimely death if you venture nearer. If you are beyond his striking distance and you hold your position, he will uncoil and crawl away, unless you annoy him. In the Arbuckle Mountains there are various species of these rattlers; the writer has observed that some specimens had as many as seventeen rattles besides the button, implying as many years.

You may be on foot in the open range when suddenly a near-by herd of cattle will follow the leader and charge you, for these animals are not accustomed to seeing a man except on horseback. On the other hand feral horses will come right up to you and beg you to pull the ticks off their breast. In the wild places your saddle-horse will not leave you even if you turn him loose, for seemingly he, too, is impressed with the strangeness of such places. Mutual comradeship is apparent; he is your sole companion and friend and favors are reciprocated.

THE STRATIGRAPHIC SUCCESSION

More than a thousand species of marine invertebrate fossils occur in the sedimentary rocks of the Arbuckle Mountains. The names of 150 of them have been arranged on the accompanying geologic table. All the formations contain fossils, but they are more abundant in the upper Reagan, Simpson, Viola, and Hunton beds than in the Arbuckle, Sylvan, Woodford, Sycamore, and Caney. The exposures visited will depend largely upon the position of the various camps and the time at one's disposal.

The Reagan sandstone representing the upper Cambrian horizon may be examined with profit along the southwestern margin of the East Timbered Hills near the old ranch house; also in the exposures along the western edge of the Tishomingo granite. The lower portion of this formation is conglomeratic and it is only in the

GEOLOGIC TABLE, ARBUCKLE MOUNTAINS, OKLA.

System	Group	— ROCKS —		— CHARACTERISTIC FOSSILS —
PENN		FRANKS CONGLOMERATE		
MISS.		CANEY SHALE Black shales and slates with fossiliferous lime-stone lentils, 800-1600 ft.		*Lingula albapinensis, L. paracletus, Lingulidiscina newberryi caneyana, Chonetes planumbonus choctawensis, Productella hirsutiformis, Liorhynchus carboniferum, Caneyella nasuta, C. vaughani, Orthoceras caneyanum, Actinoceras.*
MISS.		SYCAMORE LIMESTONE Bluish to yellow rock 0-200 ft.		*Menophyllum, Ambocelia levicula, Productella, Chonetes geniculatus, Brachythyris peculiaris, Composita buckleyi, Proetus, Ostracoda.*
DEVONIAN		WOODFORD CHERT Limy chert and black shales 625 to 650 feet thick		*Dadoxylon newberryensis, Lingula cf. spatulata batesvillae, Leptaena rhomboidalis, Productella cf. concentrica hirsutiformis, Liorhynchus carboniferum, Spirifer moorefieldanus.*
DEVONIAN	HUNTON GROUP	FRISCO LIMESTONE Gray coquina stone 0-20 feet thick		*Leptostrophia magnifica, L. oriskania, Rensselaeria marylandica, Stropheodonta becki, Orthonychia cf. plicatum.*
DEVONIAN	HUNTON GROUP	BOIS D'ARC LIMESTONE Crystalline limestone-chert. 0-90 feet thick, average 60 ft.		*Cyrtina rostrata, Eatonia singularis, Meristella laevis, Spirifer concinna, Platyceras cf. tenuiliratum.*
DEVONIAN	HUNTON GROUP	HARAGAN SHALE Variegated marly shale and interbedded marly limestone. 0-166 feet thick, averaging 100 ft.		*Favosites conicus, Striatopora issa, Scyphocrinus (Camarocrinus) ulrichi, Callopora perelegans, Anoplia helderbergae, Atrypina imbricata, Camarotoechia bialveata, Cyrtina dalmani, Dalmanella subcarinata, Orthostrophia strophomenoides, Stropheodonta crebristriata, S. varistriata, Spirifer cyclopterus, Diaphorostoma ventricosa, Platyceras lamellosum, P. ungiforme, Tentaculites gyracanthus, Phacops logani, Dicranurus hamatus.*
SILURIAN	HUNTON GROUP	HENRYHOUSE SHALE Grayish to drab-colored shales and soft marly limestone. 0-223 feet thick. Lower 120 feet with few fossils.	Upper	*Astylospongia praemorsa, Aulopora repens, Eridophyllum rugosum, Favosites niagarensis, F. venustus, Plasmopora folis, Heliolites interstinctus, Pisocrinus milliganae, Strophonella tenuistriata, Rhynchospira globosa, Spirifer crispus, Cyrtoceras subrectum.*
SILURIAN	HUNTON GROUP		Lower	*Scenidium insigne, Strophonella prolongata, Ceraurus insignis.*
SILURIAN	HUNTON GROUP	CHIMNEYHILL LIMESTONE 3. Crinoidal member, 0-39 ft., averaging 15 ft.	Crin.	*Pisocrinus, Plectambonites tennessensis, Stropheodonta corrugata, Triplecia, Spirifer radiatus, Cyphaspis clintonensis, Dalmanites arkansas, Odontopleura arkansana, Sphaerexochus.*
SILURIAN	HUNTON GROUP	2. Glauconitic member 0-25 ft., averaging 15 ft.	Glauc.	*Callopora magnopora, Pachydicta bifurcata, Phenopora fimbriata, P. magna, Rhinopora verrucosa, Plectambonites transversalis, Cyclonema ventricosa, Illaenus ambiguas.*
SILURIAN	HUNTON GROUP	1. Oolitic member 0-12 ft., averaging 5 ft.	Ool.	*Atrypa, Schucertella, Rhipidomella, Cyclonema daytonensis.*
SILURIAN		SYLVAN SHALE 60-300 ft. averaging 150 ft.		*Diplograptus, Climacograptus cf. typicalis, Lingula, Leptobulus, Conularia, Conodonts.*
ORDOVICIAN		VIOLA LIMESTONE 3. Upper member, gray crystal line rock, averaging 300 ft.	Upper	*Pachydicta gigantea, Ptilotrypa obliquata, Rhynchotrema.*
ORDOVICIAN		2. Middle member, thin-bedded dark gray limestone, averaging 300 ft.	Middle	*Diplograptus pristis, Climacograptus typicalis, C. bicornis, Schizotreta minutula, Rafinesquina deltoidea, Conularia trentonensis, Trinucleus concentricus, Proetus parviusculus.*
ORDOVICIAN		1. Lower member, massive bedded, light-colored limestone 60-100 ft. thick	Lower	*Tetradium columnare, Phylloporina reticulata, Rhinidictya mutabilis, Escharopora subrecta, Rhynchotrema increbescens, Vanuxemia gibbosa, Cyrtolites retrorsus, Protowarthia pervoluta, Bumastus trentonensis.*
ORDOVICIAN		SIMPSON FORMATION Thick sandstone and thin limestones with interbedded greenish clay shales and marls, 1200-2000 ft. thick.	Upper	*Ischadites iowensis, Stomatopora proutana-pertenuis, Phylloporina sublaxa, Rhinidictya nicholsoni, Pholidops trentonensis, Plectambonites sericea, Strophomena filitexta, Orthis tricenaria, Herbetella bellarugosa.*
ORDOVICIAN			Lower	*Orthis costata, O. cf. holstoni, Leperditia bivia, Leperditia cf. fabulites, Pliomera (Amphion) nevdensis, Bathyurus*
ORDOVICIAN		ARBUCKLE LIMESTONE Massive and thin bedded limestones and dolomites, 5000-6000 ft. thick.	Upper	*Cryptozoon proliferum, Billingsella, Maclurea, Ophileta, Eccyliopterus, Euconia, Hormotoma, Trochonema, Orthoceras, Leperditia, Isochilina.*
CAMBRIAN			Lower	*Syntrophia, Dikellocephalus, Illaenurus*
CAMBRIAN		REAGAN SANDSTONE Coarse dark sandstone calcareous and shaly in upper part. 0-500 feet thick.	Upper	*Obolus tetonensis ninus, Acrotreta microscopia, Eorthis wichitaensis, E. remnichia, Ptychoparia romeri, P. affinis, Agraulos convexus.*
PRE-CAMBRIAN		TISHOMINGO GRANITE-COLBERT PORPHYRY Coarse red granite, pink porphyry, dikes		No fossils.

C.A.R. 1926

FIG. 7.—SUMMARY TABLE OF FORMATIONS AND CHARACTERISTIC FOSSILS, ARBUCKLE MOUNTAINS, OKLAHOMA

upper part that a stroke of the hammer reveals fossils.

The Arbuckle limestone is the thickest and most extensive formation exposed in the uplift. The lower 450 feet are also of upper Cambrian age and contain a number of unidentified species. The overlying extensive dolomite and magnesian limestone beds of Ordovician age, some 4000 feet thick, are not very fossiliferous, but in the uppermost 1000 feet of the Arbuckle, where the beds are more shaly and siliceous, fossils are not uncommon.

The Simpson formation of middle and lower Ordovician age contains abundant fossils in the wooded valleys on the south side of the Arbuckle anticline, north and west of Springer. The lower Simpson fauna is similar to the Chazy of New York and Canada, while the upper one is closely related to the upper Stones river group of Tennessee and Kentucky.

The gray Viola limestone of middle and upper Ordovician age appears massive on fresh exposures, and thin-bedded where weathered. It outcrops near the margin of the large truncated anticlines as high ridges and rounded knobs. In the small Vine dome and Dougherty anticline it occupies a central axial position. Lithologically and faunally it is divisible into three members. The lowest member is characterized by some twenty-five species which represent the latest Black River and earliest Trenton stages of New York and Minnesota. The species of the middle member are indicative of the upper Trenton stage of the Ordovician of New York. The abundantly fossiliferous beds of the upper member are characteristic of the widely spread Richmond stage of the upper Ordovician period.

The green Sylvan shale, yellowish where weathered, contains few fossils. The basal ledges exposed at the south end of Vine dome are fossiliferous; elsewhere, especially in the northeast corner of the uplift near Lawrence, tabular crystals of barite are common. The age of this formation is still problematical, but may be classed provisionally as lowest Silurian.

The Hunton group of beds, which has been the subject of a special study by the writer, may be subdivided lithologically and faunally, from the bottom upward, as follows: (1) Chimneyhill limestone, with oölitic, glanconitic, and crinoidal members; (2) Henryhouse shale; (3) Haragan shale; (4) Bois d'Arc limestone; and (5) Frisco limestone. The beds, which are well exposed, vary in thickness from place to place, and no one section contains all of them. The first and second subdivisions are Silurian in age, the third, fourth and fifth are Devonian. Some 300 species have been collected from these rocks.

The fauna of the Chimneyhill limestone is the equivalent of the Ohio Clinton and Brassfield beds (lower Silurian) of Ohio, Kentucky, Tennessee, Indiana, Illinois, and Arkansas. The many fine specimens which occur in the oölitic, glanconitic, and crinoidal members are not easy to obtain for they have to be hammered from the hard and persistent ledges.

Although the Henryhouse shale has a great development on Henryhouse Creek, the finest exposures, longest section, and most fossiliferous zones are to be found in the northeast corner of the uplift on Chimneyhill Creek and to the northward. The lower 120 feet have relatively few species, while the upper portion contains many forms. The fauna of this formation is most closely related to the Bob and Lobleville beds (middle Silurian) of Tennessee.

The Haragan shale and marly lime-

Fig. 8.—Henryhouse Creek section, south side of Arbuckle Mountains. General view looking east along the strike of the Hunton beds (treeless ridge in center). The Sylvan shale appears in the characteristic timbered annular valley on the left margin; the Woodford chert underlies the timbered belt on the right side, while the barren Sycamore limestone covers the back slope of the Woodford chert

Fig. 9.—One of the numerous shale exposures abounding with fossils. "White Mound," an outlier of the Haragan shale, three miles southeast of Dougherty, Oklahoma. The surface of this mound is literally covered with invertberate fossils, many species being the same as those found in the New Scotland beds (lower Devonian) of New York State. A student party from the University of Oklahoma may be seen busily engaged collecting fossils

stone beds are best exposed on the east side of the Arbuckle uplift from Bromide to Franks and at "White Mound" and Haragan Creek three miles southeast of Dougherty. Many bushels of fossils have been gathered from the surface of "White Mound." The formation is replete with fossils of the New Scotland stage (lower Devonian) of New York.

The Bois d'Arc limestone, being hard, crystalline, and cherty, outcrops as conspicuous hogback ridges throughout its extensive exposures. Its rather abundant fauna is indicative of the Becraft stage (lower Devonian) of New York.

The term Frisco is herewith applied to the massive bedded coquina-like limestone some twenty feet thick which rests upon the Bois d'Arc formation two to three miles northwest of Frisco. The best exposures appear in the bed and bank of Bois d'Arc creek, also in

the vicinity of Coal Creek seven miles south of Frisco. The fauna is the equivalent of the Oriskany stage, the highest member of the lower Devonian of New York.

The Woodford chert, in spite of its extensive exposures, contains but few fossils. A one-foot basal transition bed, noted at various places, contains fossils derived from the underlying formations. Fish scales in concretions and large tree trunks of *Dadoxylon newberryensis* were found in the basal layers in the northeast corner of the Arbuckles. The age of this formation is problematical; it may be in part Devonian and in part Mississippian.

The bluish to yellowish Sycamore limestone is confined to the southern and west-central part of the Arbuckle Mountains. The few fossils obtained suggest Mississippian age, but its equivalent in other states has not been determined.

The black Caney shale, being a soft rock, is well exposed in the bordering plain along the southern and eastern margins of the Arbuckle Mountain plateau. Limestone lentils in the lower part and sandy beds in the upper part contain fossils. The age of this formation is still problematical; the lower part is generally regarded as Mississippian, the upper portion as Pennsylvanian.

In the vicinity of Franks, Sulphur, Davis, and westward along the northern edge of the Arbuckle Mountains, the Franks conglomerate rests unconformably on the Caney shale and older formations. This deposit which increases in thickness to the westward represents an erosional and depositional stage following the uplift of the Arbuckle Mountains in Pennsylvanian time. To the south of the Arbuckle anticline the Franks conglomerate does not appear, but instead, a thick series of shales and sandstones, known as the Glenn formation, rests against the Caney shale. The Glenn beds are folded and upturned, and, although a rather extensive Pennsylvanian fauna

Fig. 10.—The highest formation of the Hunton Group. Massive bedded Frisco limestones of Oriskany age (lower Devonian) exposed in the banks of Bois d'Arc Creek three miles northwest of Frisco, Oklahoma

has been collected from them, the exact stage of the development of the high Arbuckle Mountains by folding and faulting has not been fully determined. Extensive deposits of Permian conglomerate, forming plains, appear across the western margin of the Arbuckle uplift.

The preceding description of the Arbuckle Mountains and the abbreviated list of the fossils found therein give but an inkling of the adventures and surprises in store for the fossil hunter who visits the region. The vari-

ous formations are clearly exposed and the fossils are well preserved. Each little shell has a story to tell of the ages of long ago. From strata to strata the species either recur or show slight variations; in the succeeding beds they are apt to be somewhat different, with new forms appearing. The student becomes impressed with this record of the life of former ages, and notes that the theory of evolution as represented in these rocks and fossils is a reality and not a fancy. To the fossil collector the Arbuckle Mountains of Oklahoma are not only a happy hunting ground, but a great treasure-trove.

IN THE HEART OF THE ARBUCKLE MOUNTAINS

Fig 11.—Beautiful Turner Falls on Honey Creek, six miles southwest of Davis, Oklahoma. The blue-green colors in the deep pool below the falls are attributed to lime-secreting algæ. The rock comprising the falls is composed of travertine. These deposits contain impressions of living plants perhaps 4000 years old. Numerous falls and travertine deposits also appear on Falls Creek three miles to the southeast of this point

The Romance of Collecting Fossil Plants

By EDWARD W. BERRY
Professor of Palæontology, Johns Hopkins University

THE study of plant fossils possesses a many-sided fascination, not the least of which is the light which it sheds on the ancient history of the earth. Its story is not merely the history of the endless succession of plants which have inhabited the earth since life began, it aims to understand and interpret these in terms of evolution, geography, topography, rainfall, temperature, and distribution. Although I said the *study* of plant fossils, to my mind the student must also be the *collector* fully to interpret his material, for there is little that is romantic in sitting in a laboratory and sorting fossils that someone else has collected. One can never be sure whether better or more complete specimens could have been secured, or of the exact relations between specimens and sediments. Palæobotany divorced from the field of geology becomes sterile.

The true student must be a traveler—he must not only be a collector, but he must see all sorts of recent ecological groupings. The reason that so much nonsense has been written about geological climates is because the majority of palæontologists live in the North Temperate Zone. I know from experience that it is impossible to sense environment from herbarium specimens or books. The motto, then, of the successful student of fossil plants is the eighth verse of the twelfth chapter of Job: "Speak to the earth and it shall teach thee."

No more interesting chapter can be found than that recounting the mystical interpretations of the nature of fossils which are to be found in the writings of the ancients. It was Martin Luther who suggested that fossils were the physical evidence of Noah's flood, and we read in the Transactions of the Royal Society of London for 1757, that the flood occurred in the fall of the year—and this because the pyritized seeds in the London clays were fully matured.

In considering what I might tell the readers of NATURAL HISTORY about the romance of collecting fossil plants, I have thought of many romantic things that are now part of the history of palæobotany, such as the wonder aroused in scientific circles in the latter part of the last century when a prolific flora was brought back to Europe from Cretaceous and Tertiary rocks outcropping within a few degrees of the North Pole; or of the fossil plants found with Captain Scott's body in Antarctica; or of the marvelous Miocene flora found in the sediments of the tiny lake of Oeningen in Baden, described by Heer; or of the plants in the mouth and stomach of the frozen mammoth in Siberia; or the unique Triassic genus found in a stone in Strasbourg Cathedral; or of the wonderful petrified cycad trunk found on an Etruscan tomb in Italy; or the plants found on the lake-dwelling sites in Switzerland and Austria which record the beginnings of human agriculture; or the remarkable flora found with the ape man (*Pithecanthropus*) in Java; or the casts of plants found in the Palæocene travertines of

Sézanne on the western front in France, which can be injected with wax and the matrix then dissolved, giving us wax flowers and fruits showing the details of long vanished plants; or those preserved in amber—perhaps the most perfect of all; but I will pass these by and confine myself to a few personal experiences. One need not fall back upon history or the work of others, for there is ample romance in collecting plant fossils so that every individual may expect to experience his full share.

As a child I collected Palæozoic animal fossils from railroad ballast and along the stone fences of Schoharie County, New York, and in later years I collected vertebrate and invertebrate fossils from very many geological horizons, but I still have a vivid recollection of the thrill—now a generation old—when I found my first leaf impression in a clay bowlder of Upper Cretaceous age, at Cliffwood, New Jersey. That a thing so perishable should have been preserved for all those ages seemed marvelous. That a bone or a shell, a coral or a trilobite should thus survive the ravages of time seemed more understandable, but that a leaf or a flower—and I have since found many of the latter—should survive for millions of years to tell us something of the vegetation of the dawn of the Age of Flowering Plants, when mammals were just starting their careers and man was a far distant promise, has never ceased to impress me.

I have since collected animal and plant fossils in many climes and always that phrase from Ezekial, "Can these bones live," has run through my mind, and I know of no human delight more satisfying than that of trying to visualize the landscape of some remote stage of earth history, peopling it with its appropriate animals and plants.

It might seem that the record is scanty. Observing the seeming universal decay of all organisms, we should expect little to be preserved, but with our three score and ten years of existence, we forget the unending ages that the earth has been writing its autobiography in the rocks—which is Geology. I have calculated that a single clay lens in the Eocene of the Mississippi embayment took several thousand years to accumulate, so that a leaf a day saved would furnish very respectable collecting for the palæobotanist.

Part of the romance of all fossil collecting is that rarely does the geologist know just what he is going to uncover. I once took thirty-nine different species of Upper Cretaceous plants from a tiny clay lens high above the base of a bluff of sand on Cape Fear River, North Carolina, discovered by finding fragments in the talus at the base and tracing them to their source. At another time, when I was wading along a stream in the Coastal Plain of Georgia, looking for exposures in the low, vegetation-overhung banks, I discovered a small clay lens, not more than fifteen inches thick and a few feet long, in the marine sands of the Upper Cretaceous. This not only furnished nineteen different species, of which nearly half were new, but also two enormous and nearly perfect lobate leaves more than a foot in diameter and belonging to a new and extinct genus.

Almost always and everywhere when you have dug and split rock till your back aches and you are ready to quit, something new or startling will be uncovered that banishes weariness and

Fig. 1.—Recent nipa palms on a tidal flat in the Philippine Islands. Similar palms grew in the estuaries of the late lower Eocene Mississippi embayment

makes you work on till sundown.

> For whenever the way seems long
> Or your heart begins to fail,
> Nature sings a more wonderful song,
> Or tells a more marvelous tale.[1]

It may be ferruginized cones of a sequoia in the Dakota bad lands or the Potomac clays; or magnificent fossil ginkgo leaves in the Bridger forest reserve, where now only spruce and aspen are to be seen; or water chestnuts (*Trapa*) in the Pliocene clays of Alabama; or the twigs of the water cypress (*Glyptostrobus*), now represented by a single species in two regions in China, found fossil at almost every Fort Union plant locality of the West, and in the Tertiary of the Gulf Coastal Plain.

Who would expect to find nutmegs and date palm seeds in Texas, and yet they were there in Eocene times, and have been collected and described. One of the most interesting of modern palms, in that it grows on tidal flats,—and few higher plants have learned to tolerate salt water,—is the nipa palm. The single existing species is found from the Sunderbunds of the Ganges through the Malayan region to the Philippines, where it competes with the mangroves for a place in the sun and in the marine mud (Fig. 1). Its characteristic fruits have long been known from the earlier Tertiary of the Old World. Then, as now, the species was distributed by ocean currents. I found them while working in the lower Eocene of Mississippi, and have since found them in western Tennessee, so that once in the long ago they circumnavigated the globe, like Magellan. Historians, especially if they are given to sentiment, like to speak of the sun that shone in Galilee or at Runnymede or in the valley of the Nile, but the first dynasty in the valley of the Nile,

[1] With apologies to Longfellow.

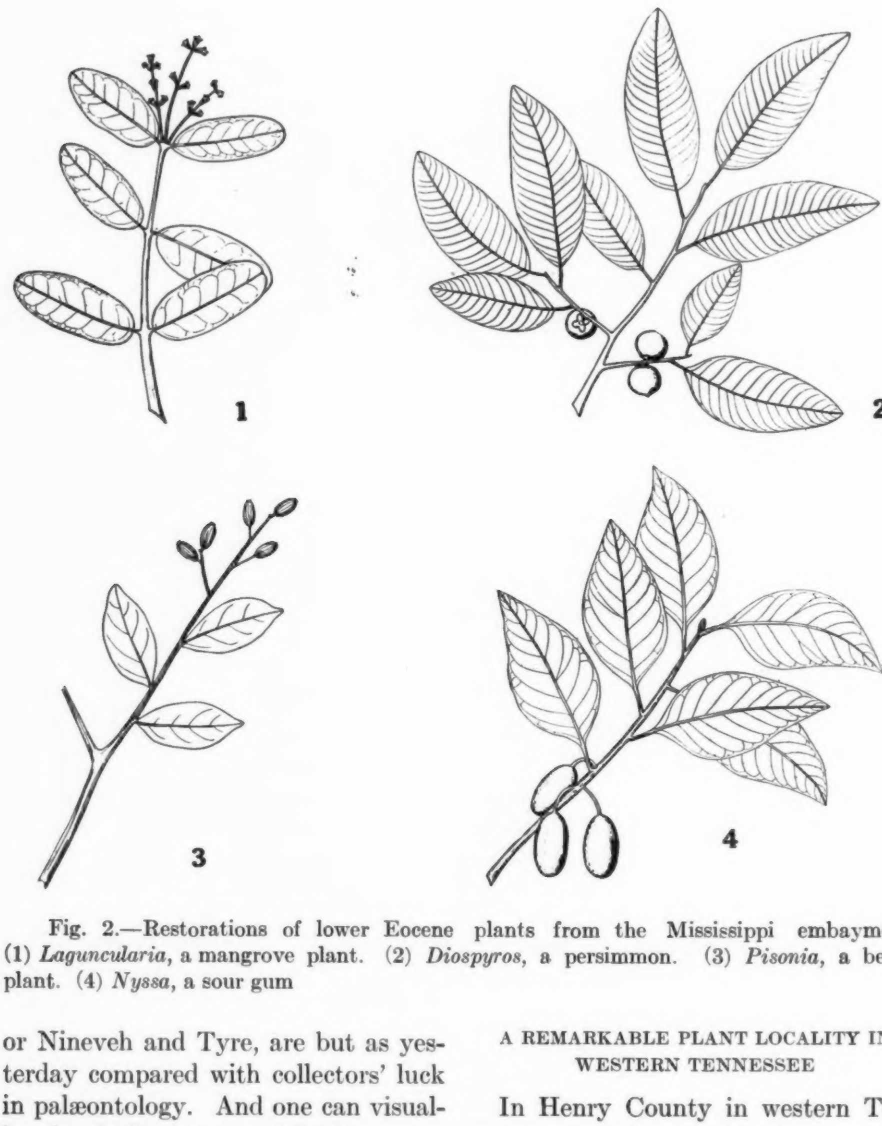


Fig. 2.—Restorations of lower Eocene plants from the Mississippi embayment. (1) *Laguncularia*, a mangrove plant. (2) *Diospyros*, a persimmon. (3) *Pisonia*, a beach plant. (4) *Nyssa*, a sour gum

or Nineveh and Tyre, are but as yesterday compared with collectors' luck in palæontology. And one can visualize the *Archæopteryx* volplaning across the Jurassic Solenhofen lagoons, or the vegetation where the four-toed horse came down to drink, or the vernal and autumnal coloration of the Wilcox shores and bayous with their appropriate plants, with the crocodiles in the sluggish waters and the hum of insects over their surface, and live through millions and millons of years in a single lifetime.

A REMARKABLE PLANT LOCALITY IN WESTERN TENNESSEE

In Henry County in western Tennessee, a series of clay lenses, with their long axes parallel with the lower Eocene coast, stretch across the county. These are of all sizes and surrounded by sands, and commercial exploitation has resulted in many workings, so that the geological relations are rather plain. At the little town of Puryear I discovered fossil plants in the clay pit shown in Fig. 5 on page 481, and not

Fig. 3.—Restorations of lower Eocene plants from the Mississippi embayment.—(1) *Parkinsonia*, an Eocene horse bean. (2) *Inga*, a characteristic leguminous tree. (3) *Engelhardtia*, a winged walnut. (4) *Dondonaea*, a beach plant

more than an acre or two in area. This was nearly twenty years ago, and a few hours' collecting at that time resulted in over 200 pounds of beautiful plant fossils. I have revisited this locality a number of times and it has turned out to be the most prolific locality for lower Eocene plants in all of North America. The remarkable number of over 200 species have been discovered at Puryear, including leaves, flowers, and fruits—all wonderfully preserved,—and these are sufficient to give a very good idea of

Fig. 4.—A view from Florida which reproduces the appearance of Puryear in lower Eocene time. Photograph by Walter B. Jones

the appearance of the region in the early Tertiary.

The coast was low and the streams sluggish, emptying into lagoons behind wide barrier beaches, which were mostly forested. The accompanying photograph, taken in Florida by Walter B. Jones, will serve to give some idea of Puryear in the lower Eocene. (Fig. 4.)

I could not begin to enumerate even the more interesting of these finds, or the vista they give of the long ago in the earlier part of the Age of Flowering Plants. The beaches were covered with bowers of wild figs, fan palms, coral beans (*Sophora*), cocoa plums (*Chrysobalanus*), sea grapes (*Coccolobis*), beach almonds (*Terminalia*), soapberries (*Sapindus*), horse beans (*Parkinsonia*), paradise trees (*Simaruba*), iron wood (*Bumelia*), sword beans (*Canavalia*), and many other forms allied to those still living in Florida, Central America, and northern South America. On the muddy bottoms were black mangroves (*Avicennia*) and other plants of the mangrove type (*Laguncularia*, *Conocarpus*, *Combretum*). The bayou margins were densely forested with the bald cypress (*Taxodium*), custard apples (*Anona*), rosewood (*Dalbergia*), cinnamon or camphor trees (*Cinnamonium*) and many other members of the laurel family, including an Eocene representative of the avocado or alligator pear—in fact, only in northern South America do we find such a variety of Lauraceæ at the present time. Other interesting things were the rain tree (*Pithecolobuim*), dilly (*Mimusops*), mastic (*Sideroxylon*), tropical cedar (*Cedrela*), cycads like the existing Florida zamias, a citrus tree (*Citrophyllum*), representatives of the family to which the Asiatic tea plant belongs (*Ternstroemites*), persimmons (*Diospyros*) of several kinds, represented by both foliage and the characteristic concrescent cruciform calices that subtend the soft fruits.

Among the more exotic finds are the leaves and winged fruits of a tree belonging to the walnut family (*Engel-*

hardtia and *Oreomunnea*) with a single existing species in the uplands of Central America and several others across the Pacific in southeastern Asia. This is quite unlike our familiar walnuts and hickories in that the nut, instead of becoming large and bony and dependent on rodents for dispersal, remains small, and the bracts expand into large wings. We infer that this second method turned out to be less efficient in competition, for the walnuts and hickories are found over a much greater area at the present time. Where I had both leaves and flowers or leaves and fruits, I have prepared life-size restorations of many of these Eocene plants from Puryear, and a few of these very greatly reduced, are shown in Figs. 2 and 3.

Fig. 5.—The clay pit at Puryear, Tennessee, is the most prolific lower Eocene plant locality in America

A GLIMPSE AT A LOWER MIOCENE FLORA AT ALUM BLUFF

When the Chattahoochee River, which forms a part of the boundary between Georgia and Alabama, reaches Florida and joins the Flint River, it becomes the Apalachicola. About halfway across Florida to the Gulf, the east bank of the Apalachicola consists of a series of high bluffs which are in striking contrast to the low country west of the river. One of the longest of these is Alum Bluff—a classic locality of the so-called old Miocene and one that has been visited by a number of geologists.

I made my pilgrimage in the summer of 1910 and found the difficulties of the trip well repaid. In the wooded damp ravines along the bluff are to be

found two of the rarest and most restricted gymnosperms—survivors from a long line of Mesozoic ancestors. These are *Taxus floridana* and *Tumion taxifolium.* They are much alike in appearance, but the latter has a very distinctive odor which has given rise to the popular name of stinking cedar, although it does not resemble a cedar, and the odor is not unpleasant, being much like that of the crushed foliage of a tomato plant. *Taxus* is found on all the continents except South America and Africa, but is widely scattered. The nearest species of *Tumion* is a somewhat restricted form in California and two others occur in eastern Asia. Obviously, such a range is indicative of great age and a distinguished ancestral line. More than a dozen of these ancestors have been discovered as fossils in different parts of the Northern Hemisphere, and although some are based on somewhat uncertain material, several are conclusive, and these show a Holarctic distribution in the Cretaceous. One Upper Cretaceous form found from North Carolina to Georgia is practically identical with the living Alum Bluff form and is probably its direct ancestor. Even as late as Pliocene times one of the living oriental species is common in Europe, and it would seem as if the continental glaciers of the Pleistocene are largely responsible for the present distribution of the genus.

Fig. 6.—A famous plant locality—Alum Bluff, on the Apalachicola River in Florida

The sediments exposed along Alum Bluff give an interesting, as well as instructive vista into the history of the earliest Miocene in this part of North America. At the base of the bluff one sees a few feet of marine sands packed with molluscan shells. This is the Chipola marl. The lower

Miocene sea was shrinking and, in the overlying ten feet, we can read the events of long ago quite as well as if they were recorded in cuneiform writing or Egyptian hieroglyphics. As the shallow sea with its prolific marine life withdrew, the sediments became more coarsely sandy with mud streaks, and these are filled with the vegetable débris of the wooded coast. Among these are packed masses of the detached and frayed rays of a fan palm like the modern palmetto. Here and there are the impressions of leaves on mud-films in the sand.

These are very fragile, and special means had to be devised for their preservation. My improvised method was to make hollows in the sand, lay a piece of burlap in this and then fill it with plaster of Paris. The specimens were sunk in this so that just the face showed, and after the plaster of Paris hardened, the whole was then removed and the loose margins of burlap tied over the face of the specimen. In this way, all the material collected effectually withstood the freight journey by river boat and train to Baltimore.

Lower Miocene plants are extremely rare in North America, and these at Alum Bluff give us a picture of the vegetation along the shore of the sea at this time, as this shore emerged to remain a land mass during all of the middle Miocene and to sink beneath the waves again in the upper Miocene, for the upper forty to sixty feet of the bluff consist of muddy sediments full of marine shells of that time, constituting the Choctawhatchee marls—more than a million years of history recorded in less than 100 feet of bluff.

Among the interesting lower Miocene plants found here were an abundance of fan palms, their leaves covered with spot fungi. Here grew elms (*Ulmus*), buckthorn (*Rhamnus*), camphor (*Cinnamonum*), satin wood (*Fagara*), iron wood (*Bumelia*), persimmons (*Diospyros*), and several less well known types. One of the oddities was the bread fruit (*Artocarpus*), a type now native only in the Orient, but common in North America from the late upper Cretaceous through the earlier Tertiary. This Alum Bluff form is its last native appearance in North America, although today it thrives in cultivation in the American tropics. Just why it should have become extinct and yet flourish when reintroduced is one of those palæontological mysteries equally exemplified by the camphor tree. This is present in North America from the upper Cretaceous and is, like the bread fruit, confined to the Orient in the existing flora, and yet the planted trees have been seeded widely over peninsular Florida by birds and effectually naturalized. A parallel example from the animal kingdom is furnished by the history of the horse, so common in the past in both Americas and yet entirely extinct when America was discovered by the white man, flourishing exceedingly and running wild when reintroduced.

The Alum Bluff section not only gives us a picture of shrinking and expanding seas with the passage of Miocene time, but the flora shows distinctly that the warm moist climate of Eocene and Oligocene times in this region was becoming cooler and that temperate forest types were gradually replacing the older more tropical types.

A TROPICAL FLORA ABOVE TREE LINE IN BOLIVIA

One of the main objects of the Williams Expedition of the Johns Hopkins University was to secure evidence

of the time of uplift of the Andes. Because of the peculiar climatic conditions induced by the elevation of this great mountain mass across the paths of the trade winds and the roaring forties, fossil plants proved to be of prime importance in determining past conditions and changes of elevation. With the exception of the localities in southern Chile and that at famous old Potosí, which had been known for some years, it was a case of hit or miss search over a thousand miles of mountain trails. Having heard of the discovery of lignite near Cochabamba, I determined to try to visit the site. Our journey from Sucre—the attractive old capital of Bolivia—was made by automobile. Sucre itself lies in a fertile basin at an elevation of 9149 feet, and is in many ways the most cultured town in Bolivia—with what remains of the oldest University (Chuquisaca) in South America next to San Marcos at Lima. There is a flourishing Geographical Society, now more than fifty years old, a National Library especially rich in early works. The life-size oil portraits of bishops and archbishops in the Metropolitan go back to 1551.

An early start took us across the red sandstone divide between the Amazon and La Plata drainage systems. By ten o'clock we had gotten down to 6700 feet in the arid zone with the largest tree cacti I have ever seen and, where it is possible to irrigate, there are haciendas with oranges, bananas, and sugar cane. Going on down the Rio Chico valley, we picked fine alligator pears at 5200 feet. At 4500 feet, where we crossed the Rio Grande, which is the boundary between the provinces of Chuquisaca and Cochabamba, the temperature was very oppressive. From here onward the trail rose to 7200 feet at Aiquile—a local center for the manufacture of *chicha*—where the night was spent. The second day was one of gradual ascent toward the divide. At around 8500 feet there were many thickets of Dodonaea—commonly thought of as a strand plant, and groves of *Podocarpus*. Near the divide, which has an altitude of 12,000 feet, I caught my first glimpse of one of the strangest plants in existence, a gigantic terrestrial bromeliad (*Pourretia gigantea* Raimondi), erect in habit, and, when in bloom, more than twenty-five feet tall.

From the divide the journey was rapidly downward into the Cliza basin and the town of Arani, from which place to Cochabamba there is nothing startling along the trail.

Cochabamba impresses one as a most delightful place. Situated in a wide agricultural basin on the Rio Rocha—which on its way to the Atlantic becomes successively the Rio Grande, Mamore, Madeira, and Amazon—one does not use up all one's vitality just to exist, as one does at higher altitudes. Here life is easier, people are happier, the food is better—although I cannot say I learned to love the *pièce de resistance* at the Gran Hotel Union, namely, sheep's brains served in a neatly sawed half of the skull—on the half shell as it were.

However, fodder and animals are cheap. Next to the Yungas, I would choose Cochabamba as an ideal Bolivian climate. One sits comfortably in the flower-bedecked plaza under a mahogany or Jacaranda tree and sips lemon or limeade, cooled with ice brought from the glacier of Tunari in the Sierra, northwest of the city, and who is there "with soul so dead" that he would not prefer ice from a

Andean glacier to any from a sanitary ice machine, especially when there are none of the latter within a thousand miles?

The usual long-drawn-out routine of getting mules and *arriero* and getting started, which is almost a religious rite in the Andes, having been gone through with, a start was made bright and early one morning. The way lay northward over the immense detrital fans that skirt the Sierra north of the city. The trail was not an important one, and hence one of the worst I ever encountered, switchbacking up the Sierra. Its character may be gathered from the statement that it took five hours to make the four leagues to the divide. The divide was a bold mass of Bilobites sandstone (Ordovician), 14,625 feet in altitude, and the going was cold and windy. The trail led down a little valley beautifully glaciated to the Finca Palca at 11,700 feet, where we passed the night. The finca was the usual one-story windowless affair on two sides of the patio, with sheds forming the two other sides. The kitchen was at one corner, the dining room at the other. Across the patio a lariat was hung with the dismembered parts, both inside and out, of a recently butchered calf, to dry and catch the dust of the score or more of Indians that tramped in and out day and night, for we happened in when the national drink of *chicha* was being made. The firewood was of tropical species covered with dried orchids and other epiphytes and shreds of lianas from the mist-covered Yungas but a short day's mule ride beyond. We were lodged on an adobe ledge in the potato (chuña) storeroom, since there was no guest room, so that whenever our fitful slumbers with the potatoes were broken, we looked out on the bright fires where the Indians were cooking their 600 pounds of corn meal for the approaching *fiesta*.

The plant locality was three miles east of Palca. Here on the wind-swept pampa, at an altitude of 11,800 feet, is a series of lignite seams, beds of clay, and volcanic ash which must have come from a great distance, and in them leaves and fruits of tropical rain-forest plants, such as the fern genus goniopteris, heliconias, gleichenias, cherimoya leaves, rain trees, iriartia-like palms, laurels, and many others indicating a late Tertiary age (Pliocene) and a much lower altitude. Thus it was determined that this great mountain mass had been uplifted between 6500 and 9000 feet since this flora was entombed, so that its site was occupied by a glacier during the Pleistocene, the beautiful terminal moraine of which is to be seen a short distance down the valley.

I might go on indefinitely with similar extracts from the notebooks of a field geologist, but the last locality was about as near Heaven as the palæobotanist is privileged to collect, and may well afford a stopping place. I am quite sure that anyone who has once laid his hand on the altar in the temple of science will never be satisfied with any other career, and will pass happily through his allotted span.

SURFACE OF A MISSISSIPPIAN LIMESTONE LAYER COMPOSED LARGELY OF BROKEN BRYOZOAN COLONIES, MOST OF THEM BEING DELICATE, LACELIKE FORMS

Fossil Collecting in the Mississippian Formations of the Mississippi Valley

By STUART WELLER
Professor of Palæontologic Geology, University of Chicago

MANY years ago the writer was collecting fossils from a locality in northern Arkansas which had been visited frequently by geologists, when an old negro strolled along and seated himself upon a log at a little distance. After the usual salutation of "Howdy," he remained silent for some minutes, closely watching my movements. Finally he broke the silence.

"Say, Mister, I wish you'd tell me the reality uv all that."

I replied, "What do you mean?"

Said he, "Fellers hev been comin' to this here rock pile fur a good many years, breakin' rocks jes like you, and you-all don't spend your good money comin' here this-a-way without gettin' somthin' out uv it."

Of course it was hopeless to attempt to instruct the old negro in the problems of Palæontology, but finally, after being shown some of the fossil shells, which meant nothing to him, and after carrying on a general conversation for a half hour, he departed, probably with the idea that he had been talking with either a fool or a crazy man, perhaps both.

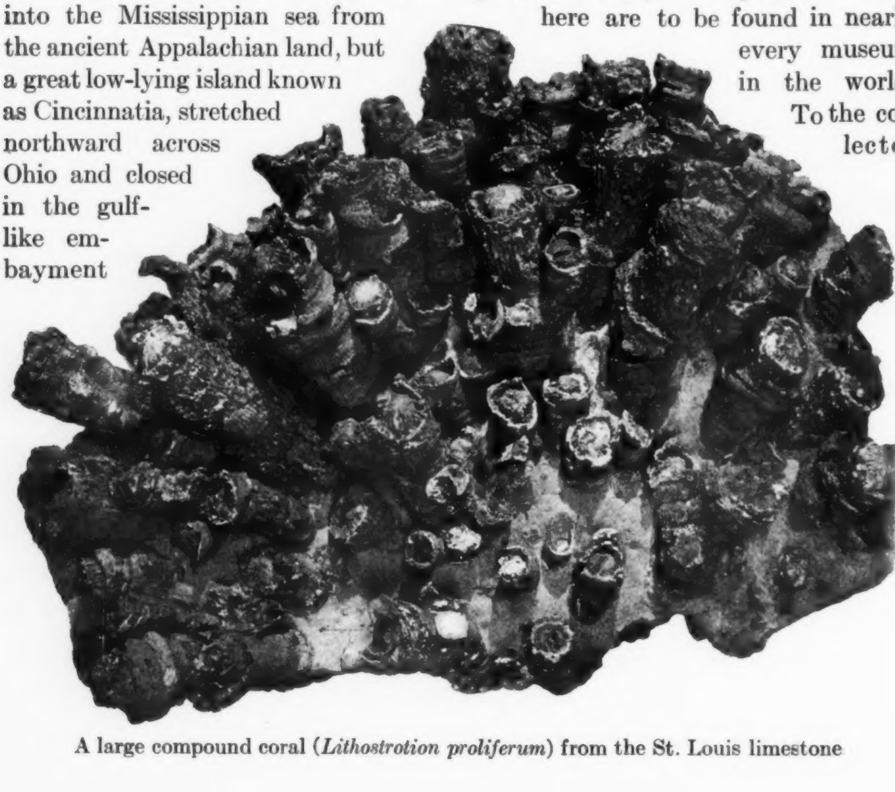
Many collectors of fossils have been actuated by the mere joy of collecting and possessing the strange objects which they could find in the rocks, who have never really come to appreciate the true purpose of the palæontologist. Ofttimes such collectors have brought together many rare and beautiful specimens which in time not infrequently have found a resting place at last in some one of our great museums. Other collectors, some of them starting as mere boys, have finally come to be counted among our leading palæontologists. Indeed, most of the outstanding men in this line of endeavor have begun their careers as fossil collectors, and no one has really attained eminence in palæontological work who is not also an ardent collector. Palæontologists and fossil collectors are born, not made, and no one who has discovered himself to be marked in this manner has ever been able completely to abandon the calling.

There is no field for the fossil collector in this country that is more fascinating than the great series of Mississippian rocks so well exposed in the Mississippi Valley region. The rocks which are included in the geologic period technically known as the Mississippian, have their great development in Iowa, Illinois, Missouri, Indiana, Kentucky, and Arkansas. Of course, they extend outside these states to the Rocky Mountains and beyond in the west, and to the Appalachians in the east, but their more typical exhibition is in the states mentioned. The fossil collector in these rocks does not find the wealth of trilobites which so delight the hearts of collectors in the older Palæozoic rocks, but oh, the joy of finding a beautifully preserved crinoid, or a whole colony of them, or of finding a new locality where any of the many forms of life in these rocks are more than usually well preserved. The fossil collector really may be engaged in some more prosaic sort of geological

work, but if he lights upon a good fossil locality he usually camps there until the sun goes down.

The interior Mississippian seas of North America were of wide extent, the waters in them were not deep, perhaps nowhere more than one or two hundred feet, so that the sunlight could penetrate to the bottom. The surrounding lands to the north and west, at least in the earlier Mississippian time, were low-lying, so that comparatively little land-wash material was brought into the sea by rivers, and most of that which was brought in was in the form of fine mud which was not distributed far from shore. Under these conditions the waters were for the most part clear and pure, and were wonderfully suited as a place of abode for the beautiful sea lilies or crinoids. To the east much coarser sediments were brought down into the Mississippian sea from the ancient Appalachian land, but a great low-lying island known as Cincinnatia, stretched northward across Ohio and closed in the gulf-like embayment to the east, which was the recipient of these terrestrial sediments, and prevented the spread of the muddy waters into the great expanse of clear-water sea lying west of the island.

One of the most notable of the formations of this great clear-water sea was early known by the pioneer geologists as the "Encrinital limestone," because it was constituted almost wholly of the remains of crinoids. Later geologists have adopted the custom of applying geographic names to formations so that this formation is now known as the Burlington limestone, from the city of Burlington, Iowa. As early as the middle of the last century, Burlington became known as a famous crinoid locality; the exposures thereabout have furnished the original or type specimens of a great number of species of these graceful forms, and specimens from here are to be found in nearly every museum in the world. To the collector



A large compound coral (*Lithostrotion proliferum*) from the St. Louis limestone

today, however, the locality is disappointing. The early collectors gathered a crop of specimens that had been maturing through the processes of weathering for many thousands of years, but at this time, although an occasional specimen can be found, he is a lucky collector who finds a really fine specimen. Although perhaps 80 per cent of the rock itself is composed of crinoid fragments, mostly broken stems, the uninjured bodies of the creatures are rare.

Another locality where a host of beautifully preserved crinoids has been collected from rocks somewhat older than those at Burlington, is near Le Grand, Iowa. At this locality crinoids different from those at Burlington, but present in great numbers and variety, were collected from a large railroad quarry, now long abandoned, and perhaps not a single specimen has been found here in the last twenty-five years, although if quarrying operations were resumed more would likely be found. Another one of the world-famous Mississippian crinoid beds is near Crawfordsville, Indiana, but this locality, too, has been worked so extensively that the collector is no longer repaid by visiting it, and he could secure the beautiful fossils only through excavation so expensive as to be prohibitive. Keokuk, Iowa, Sedalia, and Boonville, Missouri, as well as Canton and Bono, Indiana, are collecting grounds for Mississippian crinoids, largely with a past.

Notwithstanding the depletion of available specimens in many of the more famous Mississippian crinoid localities, the collector with a keen eye not infrequently comes upon choice examples of these forms at many localities throughout the region where the lower Mississippian rocks form the surface exposures.

A crinoid from Keokuk, Iowa, (*Lobocrinus nashvillae*), with the arms lacking, but exhibiting a part of the stem, the body, and a portion of the proboscis with a row of prominent spines

(Left) Crinoid (*Pachylocrinus missouriensis*), exhibiting a portion of the stem, the body, most of the arms, and the ventral sack between the arms; from Alton, Illinois.

(Right) Crinoid (*Megistocrinus nobilis*), showing the stem, body, and arms; from near Legrand, Iowa

The more modest blastoids, bud-shaped forms attached by a stem to the sea bottom during life (as were their cousins the crinoids, animals remotely related to living starfishes notwithstanding their plantlike habit of growth), lived with the crinoids in these clear seas, although they became far more numerous in later Mississippian time. A much different type of life in these rocks is the bivalve-shell-bearing brachiopod. Well-preserved fossil remains of these creatures occur much more widely distributed in the Mississippian rocks than do the crinoids or blastoids, and on a trip into the field the collector will in most cases carry home more specimens of brachiopods than anything else. Scarcely a quarry, large or small, or roadside ledge, or exposure along the streams, will fail to furnish some examples of brachiopods, although they are much better preserved and more interesting to the collector in some localities than in others. These shells

Crinoid (*Onychocrinus exculptus*), from near Crawfordsville, Indiana

A small slab exhibiting several different species of "sea lilies" or crinoids, from near Legrand, Iowa

A solid spiral axis of Archimedes (*Archimedes wortheni*) with the lacelike extension removed

A spirally growing bryozoan colony (*Archimedes invaginatus*), with the solid axis and the lacelike extension from the spiral axis

exhibit a great variety in form and size and belong to many genera and species. The writer at one time collected a large number of complete and full-grown examples of a small species of brachiopod from one of the Mississippian formations, and on filling a cubic centimeter measure with the specimens, found it to contain more than 300 individuals. On the other hand some of the largest of our known brachiopods, four or five inches across, occur in these Mississippian formations.

The moss animals or bryozoans are related to the brachiopods biologically, although the two are as different in appearance, when fossilized, as any two animals could well be. The bryozoans grow in colonies, as do many of the corals, and the individual animals are far more minute even than the small brachiopods that were just mentioned. Many of the Mississippian bryozoans grow in colonies which remind one of some delicate lace. In some localities, especially where the limestone beds are separated by thin clay or shale layers, these fossil bryo-

zoans occur in innumerable examples. Besides the lacelike forms there are others which grow in dendroid or tree-like branching colonies, the branches varying in size from the diameter of a pin to that of a lead pencil or larger. A few forms are present also which grow in quite massive colonies. The collector who becomes interested in these forms will be rewarded by finding a great variety, more than fifty genera and probably 350 species being already named and described from the Mississippian rocks, while there are many others which are still new to science.

At certain horizons and in certain localities the fossil collector in the Lower Mississippian rocks can find a large number of the shells of snails and clams, most of them of comparatively small size, but mollusks of this sort are far less conspicuous in these faunas than in those of some of the other geologic periods. The chambered cephalopod shells are even less in evidence than the other mollusks, although in a few localities they are known to occur in considerable numbers.

Some corals lived in these seas, but most of them were simple, horn-shaped forms. A few colonial assemblages are present in some horizons, but nowhere do they seem to have had the reef-building habit which is so conspicuous among these creatures today, and which had also been established in some of the periods older than the Mississippian. In some other parts of the world during Mississippian time, coral reefs were in existance, but conditions were not favorable for them in the great interior sea of North America. The remains of an occasional sea-urchin and starfish are stumbled upon now and then by the collector in these rocks, but the starfish especially is exceedingly rare.

All the fossil forms which have been mentioned belong to the invertebrate phyla of the animal kingdom. The vertebrates were represented only by fishes, and all these fishes were related to our sharks. These creatures had no bony skeleton, their framework being wholly cartilaginous. The only hard parts capable of fossilization were the teeth and fin spines. These objects are likely to be met with almost anywhere by the collector of Mississippian fossils, and almost always they can be recognized by reason of their bla k or dark brown color, in sharp contrast with the lighter colored limestone in which they are commonly imbedded. A close examination always discloses a characteristic bony texture of these fossils. These Mississippian sharks were of two distinct types: first, the pavement-tooth forms in which both the upper and lower surfaces of the mouth were set with flat, crushing teeth, similar to blocks in a pavement, undoubtedly used for crushing the shells of brachiopods and other creatures upon which they lived, and second, the sharks with sharp-

A large Mississippian brachiopod (*Spirifer grimesi*), from Springfield, Missouri

pointed teeth which more than likely preyed upon their pavement-toothed relatives.

In passing from the lower or Iowa Series of the Mississippian into the upper or Chester Series, a notable change took place in the outlines of the seas themselves, in the character of the sediments accumulated, and in the faunal associations which inhabited the seas. In the Mississippi valley the Chester sea occupied a somewhat restricted embayment lying between the Ozark land in Missouri, and the island Cincinnatia already mentioned. The head of this embayment was near the middle of the state of Illinois. To the south the sediments of this age cross Kentucky and Tennessee, and extend into northern Alabama and Georgia. In a southwesterly direction formations of similar age are known across Arkansas, Oklahoma, and as far away as southwestern Texas.

A nearly perfect trilobite (*Phillipsia portlocki*), from the Crawfordsville, Indiana, crinoid beds

The Chester Series was named from the city of Chester, Illinois, and the most extensive collections from these formations have been made in Illinois and Kentucky, although highly interesting fossil localities are known elsewhere.

The fossils to be found in these rocks are much different from those of the limestones of the Iowa Series. The Chester sea was not so dominantly a clear-water sea, and the difference in environment doubtless had its effect upon the animal life which inhabited it. The crinoids are still present, but they have completely changed from those of the older beds, and there are no such thick limestones made up almost exclusively of crinoid remains. Only rarely does the collector find a complete crinoid body, but among the oddities which he is likely to meet with almost anywhere in the Chester, are the so-called wing-plates of a peculiarly specialized "wing crinoid." A great variety of these plates may be found. The blastoids or bud-shaped echinoderms are much more abundant than the crinoids, and in some localities many beautifully preserved examples, belonging to numerous species, can be gathered. One locality in southern Illinois known to the writer, is visited on every possible occasion; every visit is sure to be rewarded with fifty or more beautifully preserved specimens, and occasionally a good crinoid is also found.

One of the most conspicuous types of fossils in the Chester faunas is the bryozoa. At this period of geologic history most of the species of these creatures were delicate and more or less fragile colonies, many of them lacelike in appearance. In some locali-

ties great numbers of Archimedes screws, the supporting axis of one form of bryozoan colony, can be gathered. These screws and the blastoids are perhaps the most characteristic of all the Chester fossils. Another of these bryozoan colonies is supported by a broad U-shaped calcareous base, examples of which are met with in many places.

The shells of brachiopods are exceedingly common in the Chester formations, and in some localities hundreds of specimens of a few species can be gathered easily, but the variety of species is much less than in the limestone of the Iowa Series. Locally many examples of the shells of clams and snails can be collected in some of the Chester formations, but most of them are small, and many of them are as yet undescribed species. The fishes which swam in the Chester seas were all sharks, related to those of the lower Mississippian formations, and their spines and teeth, either the pavement type or the pointed ones, are likely to be met with by the collector in any of the fossil-bearing beds of the series.

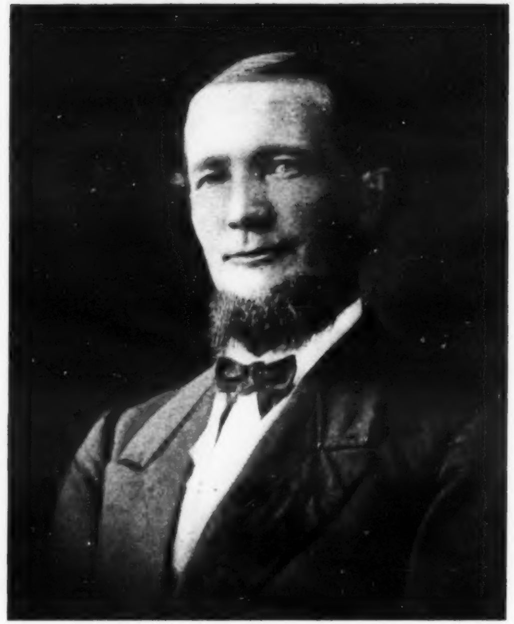
The most interesting localities for the collector of Chester fossils are certain calcareous shale beds which in places are exposed in glades, most commonly upon southern hill slopes, in southern Illinois and Kentucky. Where a favorable locality of this sort is found, there is little or no vegetation present, and the fossils occur weathered out clean. To gather the specimens the collector lies flat upon the ground with his face close to the surface, and picks and picks and picks the fossils, most of which are small. Probably the great majority of forms belong to a few species, but he is always expecting to find one of the rare ones next, perhaps a well-preserved crinoid body. In a really good locality of this sort, as many as sixty or seventy or even more species may be gathered.

There still remains a broad field in the interior of our country for the investigation of the collector of Mississippian fossils. Many new localities

The pointed tooth of a shark (*Cladodus splendens*), from the Mississippian limestone near Legrand Iowa

of great interest will certainly be discovered in the years to come. Within a few years a number of glacial bowlders with typical Mississippian fossils of Mississippi valley types, were found in a clay pit in Chicago, showing that somewhere to the north of this city, and now completely hidden by the glacial drift, there must be a Mississippian outlier that has never yet been seen by the eyes of man. Only this year a locality has been discovered in Mexico from which a characteristic lower Mississippian fauna has been secured, nearly 1000 miles from the occurrence of any similar fauna to the north. Other such discoveries will certainly be made, every one of which will help to interpret the geologic history of North America.

Wm Clark



H. Herzer

Jay Terrell

PIONEER FOSSIL-FISH COLLECTORS IN OHIO

Dr. William Clark (1826–1908), discovered many fossil fishes in the vicinity of Rocky River and Big Creek, Ohio. His collections may be found in the British Museum and in the American Museum of Natural History

The Rev. Herman Herzer (1833–1912), in 1866 discovered fish bones in the large concretions which characterize the base of the black shale at Delaware, Ohio. The same year, Newberry identified the specimens as *Dinichthys herzeri*

Mr. Jay Terrell (1827–1904), while living near Lorain on Lake Erie, discovered, certainly before 1870, fossil bones which Newberry described in 1875 as *Dinichthys terrelli*. For twenty-five years he continued to be a successful collector

Collecting Fossil Fishes from the Cleveland Shale

By J. E. Hyde

Cleveland Museum of Natural History and Western Reserve University

Upon his back a bag o' stones
His pouches fu' o' fossil bones.
—Robert Dick.

THE instinct to "collect" is a very deeply rooted human character. Almost anything can be collected, if not too bulky. The sedimentary rocks of many lands have afforded rich opportunities for collecting small invertebrate fossils; amateur collectors, however, of the remains of vertebrates like dinosaurs and mammals are few because of the size, care required in handling the bones, and the organized support required. Fossil fishes, however, are not so bulky, and consequently are the only group of vertebrates to be extensively collected by amateurs.

One recalls at once Hugh Miller and Robert Dick, who collected fossil fishes from the Devonian Old Red Sandstone of Scotland. Each had experienced that supreme joy of discovery; of standing in the presence of apparently lifeless and meaningless rock, which under the stroke of a hammer yielded a fossil fish, and thereby took on meaning and significance. Both followed the vision.

Hugh Miller, the stonecutter of Cromarty, found his first fossil fish working as a quarryman in the Old Red Sandstone. Later becoming editor of his church paper, he wrote with such success of the keen pleasure of finding fossil remains, that his writings, gathered into book form and followed by other volumes, were widely read, and played their part in preparing the popular mind for the changes in intellectual viewpoint introduced by Darwin.

Robert Dick, the shy, retiring baker of Thurso, the northern-most, bleakest village in Scotland, never missed mixing a day's batch of bread, but so timed its setting that he could start, on foot, at midnight, on a fossil hunting expedition. He remained a poor, humble baker, but he was exalted by his glimpses of creation; and his love for his native ferns, holy grass, and fossil fishes endured to the end of his modest life.

Northern Ohio has maintained a like group of collectors of Devonian fossil fishes from 1870 to the present. Engaged the greater part of the time in their daily tasks and professions, these enthusiasts searched for fossil fishes in spare moments, stimulated each other in the brotherhood, and became worthy successors of Miller and Dick. Among them are names familiar to all those who know fossil fishes.

The Rev. Herman Herzer, gentle minister, superintendent of the Berea Orphan Home, and teacher in Baldwin-Wallace College, was the first discoverer of these fishes in Ohio, and his find, *Dinichthys herzeri* Newberry, bears his name.

Jay Terrell, fruit gardner and hotel keeper was the discoverer of *Dinichthys terrelli* Newberry.

Dr. Williams Clark, physician and man of strong personality, perhaps the best known of all because of his collections in the British Museum and the American Museum of Natural History, found many fishes which now bear his name, *clarkii*.

The Rev. William Kepler, ex-soldier, minister, professor of natural science in Baldwin University, Berea, and for one year its acting president, was a noted collector. His spare time, spent on the river banks, with his son as companion, yielded important finds during years of collecting. *Cladoselache kepleri* Newberry was the contribution which served to perpetuate his name in the world of fossil fishes.

C. C. Fyler, the deaf whetstone maker of Berea, was the discoverer of *Cladoselache fyleri* Newberry.

Dr. D. T. Gould, druggist of Berea, was inoculated with the urge for fish collecting, but found it necessary first to restrain his enthusiasm, and finally to abandon the art, for running a small-town drugstore was then an exacting business. But he did not stop until after he had discovered *Stenognathus gouldii* Newberry. He is still living in Berea, nearing eighty years of age, the last of the older generation of collectors.

A. A. Wright, professor of geology and natural history in Oberlin College, Ohio, and his successor, Professor E. B. Branson, were the only ones of the brotherhood of collectors to publish any of the results of their finds.

All of the men mentioned made splendid contributions to science through the mere act of recovering the fossils from the shaly rock. The descriptions and interpretations were mostly by others, Newberry, Dean, Claypole, Smith-Woodward, Jaekel, and Hussakof. Dean was a student under Newberry, and Hussakof under Dean, and their material is in the American Museum of Natural History. The present writer was a student under Dean.

In surveying the history of our knowledge of these Ohio fishes, it is interesting to note that it has been in the hands of two guilds; the guild of collectors, the members of which drew their stimulus or enmity one from another, and the guild of scientists which gave most of the professional treatment to the material. Indeed, one suspects that Wright and Branson, named with the collectors, are of the professional caste, whose interest is, at bottom, scientific, and who do not feel so strongly the periodic desire to go out to the stream banks and "collect," an urge which, in the true collector, is as real as the rise of sap in March. It does not originate in the inquisitive spirit of the scientist as much as in the venturesome spirit of the gambler, or fisherman, to try his skill and luck against chance and a worthy combatant.

Jay Terrell and William Clark were the outstanding leaders of the guild of collectors. Terrell discovered the fossil fishes independently of the Reverend Herzer and was a very enthusiastic collector until 1890. It was he who stimulated the Oberlin group of collectors and, later, Bungart at Lorain, who is now a collector for the Cleveland Museum of Natural History. Possibly Clark would have become a great collector without the development of the disease which brought Terrell into professional contact with him. Certainly to these two enthusiasts, and to their collections and stimulus of others, is to be attributed almost wholly the accumulation on which our knowledge of Cleveland shale fishes is based.

It is almost useless for a man, untrained in the ways of the black shale, to come into the region hoping to find much. The late Professor H. P. Cushing, Cleveland-born, professor of geology in Western Reserve University

Cedar Point on Rocky River. The bank, about sixty feet high, is Cleveland shale. Fossils occur throughout, but only the lower few feet can be prospected. For twenty years Doctor Clark visited this outcrop, twice yearly if possible, for specimens of fossil fish

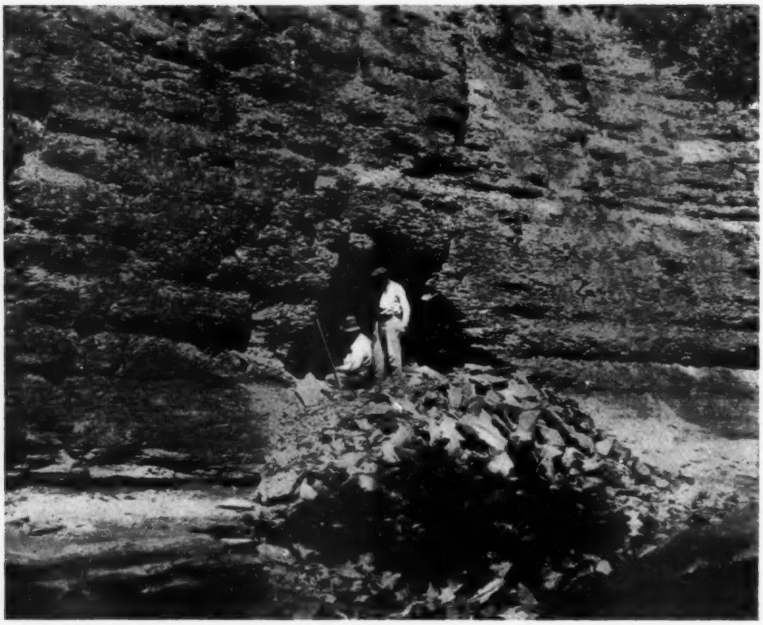
from 1892 to 1921 and a local fossil collector of considerable keenness and assiduity, told the writer that he had never found the remains of a single fossil fish. The writer although resident eleven years, and devoting three of these to active work on the shales, has made only two finds worth carrying away.

The brotherhood of collectors of the fossil fishes of the Ohio black shale will forever be a restricted one, because few possess the love of nature, the desire to collect, the ability to find, and the patience to extract and to reassemble the bones broken in fragments.

These fishes in the black shale of northern Ohio are never common and are usually exasperatingly difficult to detect in the vertical shale banks where they are best sought. Yet a northern Ohio collector reads with a queer feeling of compassion Robert Dick's enthusiasm at finding a single fish bone, of his sometimes heart-breaking labor to extract it from the great ledges of Old Red Sandstone, and of his long, patient, often unrewarded search for the complete fish.

Cleveland shale fishes are sometimes astonishingly complete. Once discovered they may yield satisfactory return after no great expenditure of labor. Only a short time ago, the author with Peter Bungart, laid bare at a single hammer stroke, an entire three-foot shark, head to tail, with fins, and a large knot of ganoid scales "amidships," the last meal which it had snapped up; a curious little episode of a moment before the Appalachians were formed 400,000,000 years ago.

The Cleveland shale is the topmost member of a mass of black, carbonaceous shales, the Ohio shale, from 300 to



Typical occurence of Cleveland shale on Vermilion River. Several years progressive excavation at this point has revealed the crushed head and body of a *Dinichthys*. The 1926 season may reveal the missing fins

1000 feet thick in Ohio, and extending entirely across the state. Fish remains are found from bottom to top and from the Lake to the Ohio River, but knowledge of them is based almost entirely on material procured from the topmost member and from within forty miles west of Cleveland. No other portion of the state has ever developed amateur collectors for these remains, and no other portion of the state presents outcrops of the shales as good and as numerous as those of northern Ohio.

Varying from 20 to 65 feet in thickness, the Cleveland shale is cut by all streams flowing northward into Lake Erie from Grand River west to Huron River, a distance of ninety miles. It is thickest, and the outcrops are much better, from the Big Creek in the western edge of Cleveland west to, and including, Vermilion River.

The Cleveland shale fishes are the largest Devonian fishes found. Entire sharks up to 5 feet in length have been obtained, but jaw cartilages 2 feet long show that much larger ones existed, perhaps from 15 to 20 feet in length. The arthrodires were of similar size. These, more than any others the world over, have caused the attributes of hugeness and ferocity to be associated with our conception of fish-dominance in the Devonian Age of Fishes.

About forty different kinds of fishes are known from northern Ohio. These fall into two groups, the sharks and the arthrodires, with very rarely a ganoid. The sharks, though primitive, were already truly sharklike and had acquired much of their present features and mode. The shark jaws and dentition were established essentially as at present. The arthrodires, destined to extinction very shortly, were heavily

armored about the head with great bony plates, but were a very plastic stock judging from the variation in character. The jaw parts show more unity of pattern and yet a greater range in character than has yet been described. They were not in the least a fixed line in the sense of lacking variation and adaptability. That they did not lack in ferocity and aggressiveness is shown by the great scars which sometimes mar the plates. Yet they did not solve the problems of living in a way necessary to meet the requirements of the great test—survival.

The arthrodires are found evenly distributed over the entire area of production and through the entire thickness of the Cleveland shale. The sharks are known from the entire area but their production is essentially confined to one stream, Big Creek. From the rest of northern Ohio, only teeth, an occasional fin, spine and jaw elements, unrelated to the rest of the creature, are known. On Big Creek have been found all of those exquisitely preserved Cladoselachians which are unique the world over among fossils. All the specimens listed in the literature as coming from Lindale (or erroneously from Linton), and Brooklyn, and most of those listed from Cleveland, were obtained on Big Creek and its tributaries.

The reason for this restriction to Big Creek is that they are there enclosed in concretions, flattened elliptical masses of siliceous and clayey iron and lime carbonate, two to five feet across. Nowhere else are such concretions found, and the flattened bodies of the sharks, though undoubtedly present elsewhere, cannot be detected in the Cleveland shale without these markers to reveal them.

Cleveland shale exposure on Big Creek near Cleveland, Ohio. The flat concretion, at the point of the pick, contained a pressed cladoselachian shark about four feet in length

In some parts of the Big Creek system, every concretion contains an arthrodire bone or a shark. In other parts one out of four concretions is productive. The art of collecting in this creek consists in locating concretions, and by the break of the surrounding shale the experienced collector can locate a concretion that is yet beneath six inches or a foot of shale.

Two mysteries are not yet satisfactorily solved: Why are no arthrodires found with bodies preserved entire in the concretions, as are the sharks? A single one with head and backbone has been found, but without traces of body outline, musculature, or filling of alimentary canal. Why are ganoid fishes essentially absent from the shales and the concretions, except as masses of scales and bones in the alimentary tract of each shark or in coprolitic masses? These two questions present a glimpse of the problem of the ecology of the fishes. It is hoped to present, in time, a statement of the environment in which this fish fauna lived.

While a shark or the head bones of an arthrodire, once discovered, may be recovered easily, experience of the last three years has proved that our lack of knowledge of the body of the arthrodires has been due to the lack of sufficient care in collecting. For fifty years the impelling instinct to collect has been satisfied with finding the bodies of sharks and the bones of arthrodires that are easily won. We now know that with very great care in extracting and with days of patient work with the dental engine and tools, much more can be regained. The scouting for these fishes is now passing from the amateur to the professional collector and preparator.

Big Creek is on the edge of rapidly growing Cleveland. Six years ago one of the lesser collectors of the past generation, Thomas Piwonka, took the writer over a part of Big Creek which had been a favorite haunt of Clark's, whom he had known intimately. We rode by trolley a mile beyond the edge of the city through fields and occasional woodlands. That mile of country

Cladoselache, a primitive shark from the Cleveland shales. The body rested evenly on the ocean floor, belly down, and after burial by mud, was compressed without distortion to a thickness of a quarter of an inch. The tail was not flattened but remained standing at a high angle so that it is foreshortened in the picture. The jaw elements and gill bars can be easily distinguished, but the spinal column and pelvic girdle are rarely preserved and are not here shown. The finer markings midway on the body are the muscles

The shallow valley of Big Creek in the outskirts of Cleveland, Ohio. During half a century this spot has produced many fine cladoselachian sharks. Twenty-six separate finds, part of them arthrodires, all in concretions, are known to have come from the bend in the foreground and a few rods to the left of the view. The city has encroached upon the limits of the area. The creek banks are of shale about one foot high. The flat valley bottom on either side is of shale covered with earth

The power shovel of the Cleveland Museum of Natural History fishing for concretions containing five-foot sharks in one-foot-deep Big Creek. On the sky-line is the encroaching city

has now entirely disappeared. Three years ago when the Cleveland Museum of Natural History undertook the collection of these fishes, another prolific branch of Big Creek lay a good

The first concretion turned up by the power shovel of the Cleveland Museum of Natural History, operating in the shale beds exposed in the valley of Big Creek. Director Rea and collector Bungart of the Museum staff are at the left

quarter-mile south of the encroaching edge. That quarter-mile has now disappeared, and houses stand almost on the creek bank.

Everywhere in the Big Creek basin streets are being laid out, lots staked, pipes laid, and houses built, and very shortly several small stream heads will be confined strictly to allotted channels or will become closed sewers. Fish collecting on this stream will then be forever closed.

In the effort to save as much as possible from this unique locality, the Cleveland Museum has obtained the hearty coöperation of one of the land companies and through the generosity of friends who appreciate the situation, has placed a power shovel on one of the branches where there is a broad shale bottom under slight cover which has been productive in the past. This bottom will be turned over, as long as the support will keep the shovel going and the turnout of fishes is good.

Here, where Clark and Kepler wandered along low, shaly banks, each in hopeful anticipation of forestalling his rival in finding a concretion exposed by the past winter's weathering or the last spring's floods, the power shovel now turns out a concretion one or two or three times a day. But though the production is increased and choice things have been recovered which would otherwise have been lost forever, the keen pleasure of search is denied the collector assigned to the shovel.

However, whether we rise at one in the morning, to walk many miles with Robert Dick in the dark through a wet Scotch mist or a wetter Scotch rain, to a seacliff of Old Red Sandstone that is sure to produce a fossil fish, or whether we get down to the shovel at eight in the morning and quit with the whistle at half past four in the afternoon, the spirit is the same—and none will ever express it better than has Dick himself:

Hammers an' chisels an' a',
    Chisels an' fossils an' a';
Resurrection's our trade; by raising the dead
    We've grandeur an' honour an' a'.

It's good to be breaking a stone,
    The work now is lucky an' braw;
It's grand to be finding a bone—
    A fish-bone the grandest of a'.

Hunting Fossil Marine Faunas in New York State

By RUDOLF RUEDEMANN, Ph.D.
State Palæontologist, New York State Museum

ONE never knows what may turn up in fossil hunting; moreover one is buoyed up by the hope of an unexpected discovery. Prof. James Hall once called the collecting of marine fossils "dry dredging," and dwelt on the fascination of diving into the depths of ancient seas with hammer and chisel. His successor, Dr. John M. Clarke, often spoke of the pleasure of fossil collecting because of the "gambling" element in it.

The best specimens are usually found when least expected. It is this that makes fossil hunting so similar to hunting game. Rare fossils will appear suddenly like grouse flushed from cover, and often the collector, excited for the moment, spoils a good find—even as the hunter misses his quarry. For instance, on the Mohawk, near Rexford, I once saw in a block of stone a beautiful seaweed surrounded by a whorl of air-bladders. I picked it up quickly, and since it was traversed by countless cleavage cracks it crumbled instantly into a thousand pieces.

One summer morning, when I was walking toward the Dolgeville High School, I saw workmen leveling a nearby hill and dumping the shale along the road. Suddenly my attention was arrested by a large starlike graptolite. I picked up the specimen and saw it was a complete stock of Utica graptolite such as had never before been found. The shale was being covered with soil as fast as it was taken from the ledge, but I persuaded the engineer in charge to let the material remain uncovered every day until my school boys and I had searched it. To arouse enthusiasm in the boys, I told them to make their own collections, and we procured the finest set of complete colonies and their growth-stages known at present. All these specimens I borrowed for study and inherited in due time when the boys had lost interest.

The Deep Kill fauna was also discovered by accident as I walked through the ravine at sunset. The light fell upon a large block dumped below the dam (then under construction) in such a way as to bring out the barely visible thin films of *Phyllograptus typus* upon the adhering shale layer. This led to the finding of the very complete Deep Kill section in steeply dipping rocks that otherwise would not have betrayed their wealth.

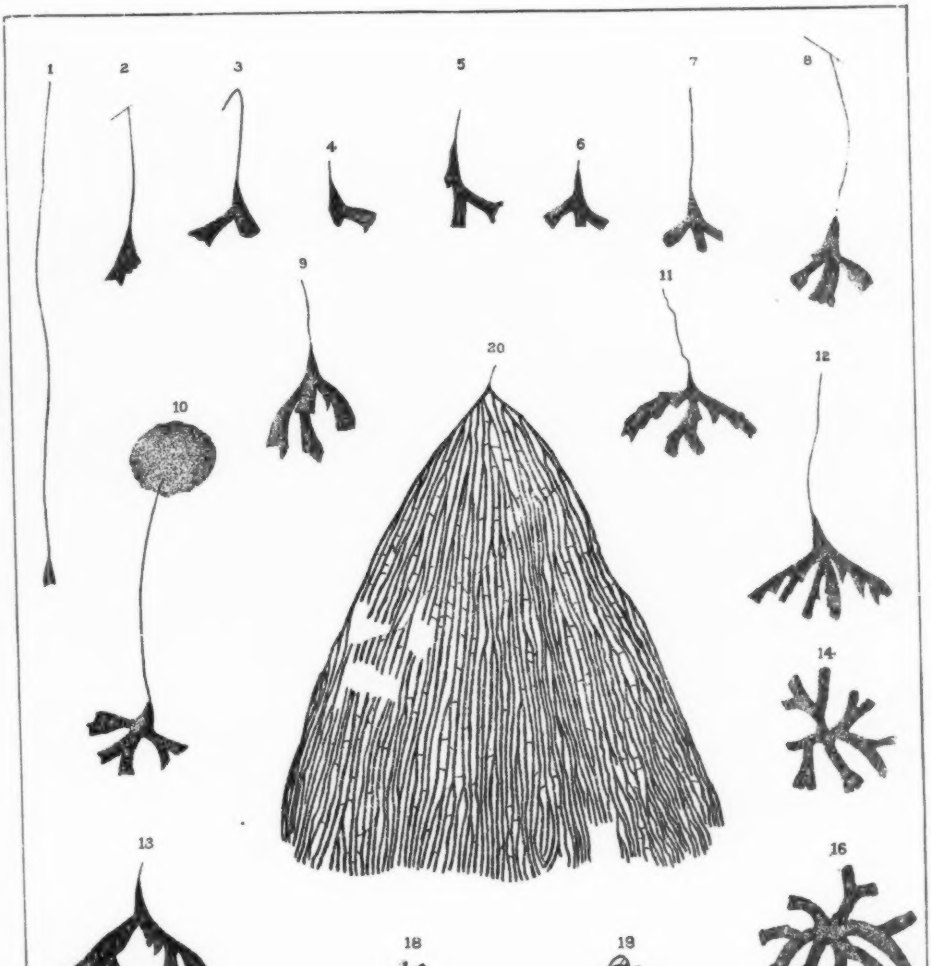
Again, on a beautiful October morning, when I was on my way home from field work, my train was passing the gorge of the Hoosic River. I decided that it was too beautiful a day for me to go home so early, so I jumped off the train at Schaghticoke and went down into the gorge. Here I found the Schaghticoke shale fauna, the oldest graptolite fauna in America.

One of the most amazing finds was made by Doctor Clarke and me when we went to Jerusalem Hill to collect eurypterids for our memoir. There were no outcrops of the rock, but there was fair collecting in the stone fences. We searched these systematically. One morning we selected a long, straight, promising fence. Doctor Clarke took one side, I the other. We had hardly reached it, when we both exclaimed: "Look at all the crinoids!" The entire fence had a top layer of

The graptolite shale in the Hoosic River at Schaghticoke, New York

large slabs of Coeymans limestone completely covered with *Homocrinus* (*Lasiocrinus*) and other crinoids, all beautifully weathered out. We could not understand at first why this treasure had been laid out ready for us to take home. There were no slabs of the kind in the fence itself. We learned afterward that many years before there lived near by a country physician, a Doctor Brown, who was a collector of fresh-water and land mollusks. To obtain material for exchange, he worked a layer of crinoids in a quarry on top of the hill, long abandoned when we arrived. The crinoid bed was covered by a thin layer of tightly adhering shale. To free the crinoids from the latter, the doctor used to expose the slabs to weathering for two years or more on that fence because it was not too near the road. He died after laying out the supply of material we discovered some twenty years later, leaving us a wonderful inheritance and testimonial of his love of nature and collecting spirit.

Eurypterids are rather elusive fossils. They refuse to turn up when you hunt for them, but delight in winking at you out of their bean-shaped eyes when you least expect them. In 1906, while the tunnel of the Erie Railroad was under construction at Otisville, Dr. H. B. Kummel, state geologist of New Jersey, telegraphed to Doctor Clarke that he had seen graptolites in the rock material brought out of the tunnel. Doctor Clarke was in Gaspé at the time, and I intended to leave within a few days for the International Geological Congress in Mexico. However, I made a hasty trip to the place, arriving in the evening and planning to leave the next noon. After I had collected what there was of graptolites, I walked along the track to the place where the Shawangunk grit rests



SCHAGHTICOKE GRAPTOLITES, INCLUDING GROWTH STAGES

ONE OF THE CRINOID SLABS LEFT BY DOCTER BROWN FOR OUR BENEFIT AT JERUSALEM HILL, LITCHFIELD, NEW YORK

unconformably on Ordovician shale, an outcrop that has been figured repeatedly. I saw a large quarry beyond, and having still a little time to spare, I went in. It was not being worked at the time, but a splendid manifold repetition of grit beds and thin black shale seams, that do not show in weathered outcrops, was exposed. "Silurian graptolites, perhaps," I thought, and began to look for them. Instead I picked up a eurypterid head and some segments, and the remarkable Shawangunk grit eurypterid fauna was discovered. This and larger collections furnished the growth-stages of eurypterids described in the joint memoir by Clarke and myself.

Equally unexpected was the discovery of the Ordovician eurypterid faunas. While studying the graptolite shale of the Hudson and Mohawk river valleys, I visited a series of quarries just outside Schenectady where "bluestone" was broken. I secured a fair collection of graptolites, brachiopods, and trilobites in the thin shale intercalations, all new to that formation (Schenectady beds), hitherto supposed to be barren. By chance, one day as I was packing my material before leaving, the reflection from the evening sun illuminated a carbonaceous patch, half the size of a penny on a bit of shale. I picked it up and there was the finest piece of eurypterid skin with the characteristic scales that I have ever seen. The next day I went eurypterid hunting with a vengeance and I obtained the collection of eurypterids of the Schenectady beds described in the memoir, the first eurypterid fauna of Ordovician age known by more than a few fragments. It was the last opportunity, for the whole district was soon built over and is now buried under houses.

A few weeks later Professor Chadwick came through Albany with his students and I showed him my new discovery. The next day he notified me that he had found a like eurypterid fauna in the Normanskill shale at Catskill. That is the oldest Ordovician eurypterid fauna known. Thus one discovery often leads to another.

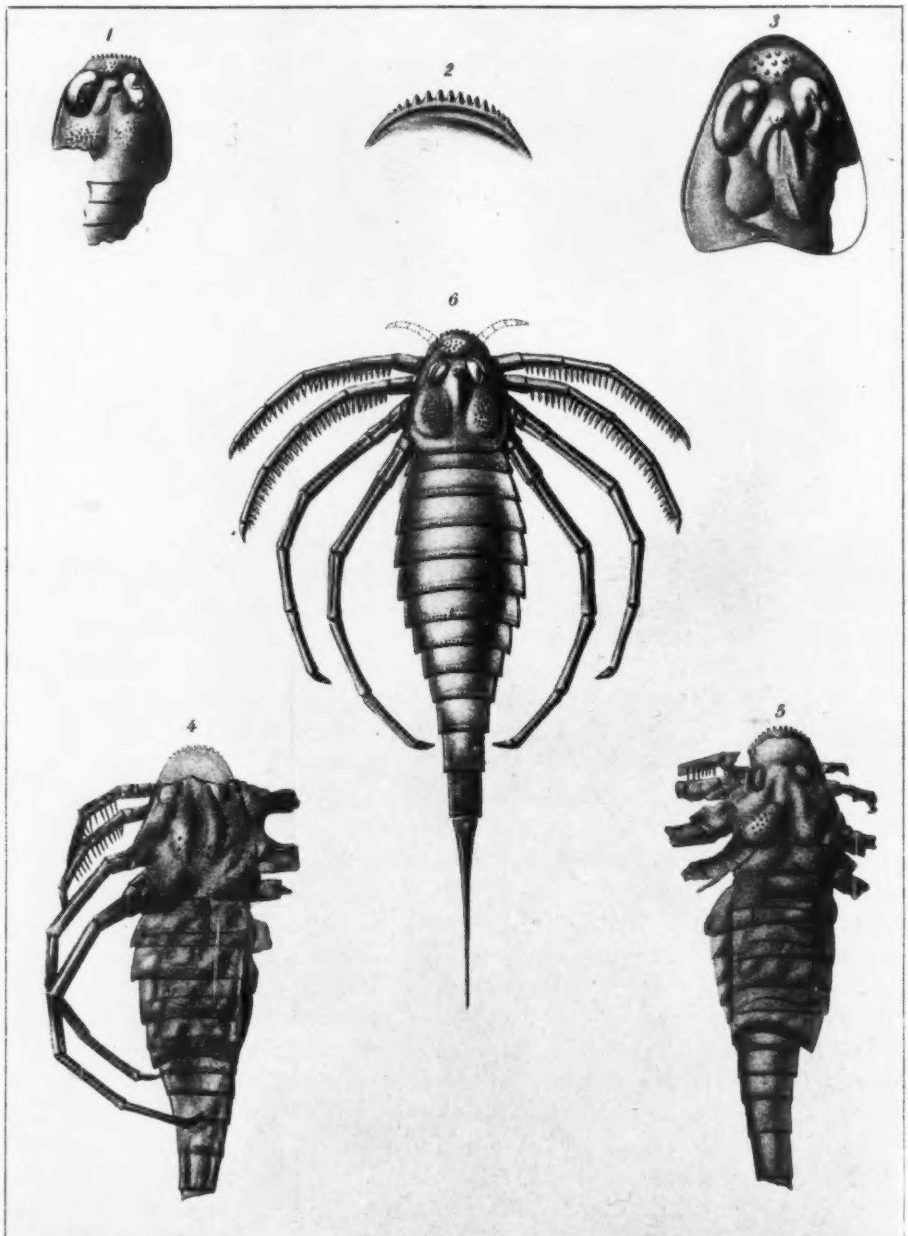
A third find of eurypterids was amusing. Two colleagues and I were at Gilboa to secure trunks of the Gilboa trees. One of them was trimming off the rock adhering to the base of a fossil tree trunk, when I remarked jokingly: "Let me have that hammer. You do not know how to handle it!"

"All right, show what you can do," he said, secure in the knowledge of his superior ability in that line.

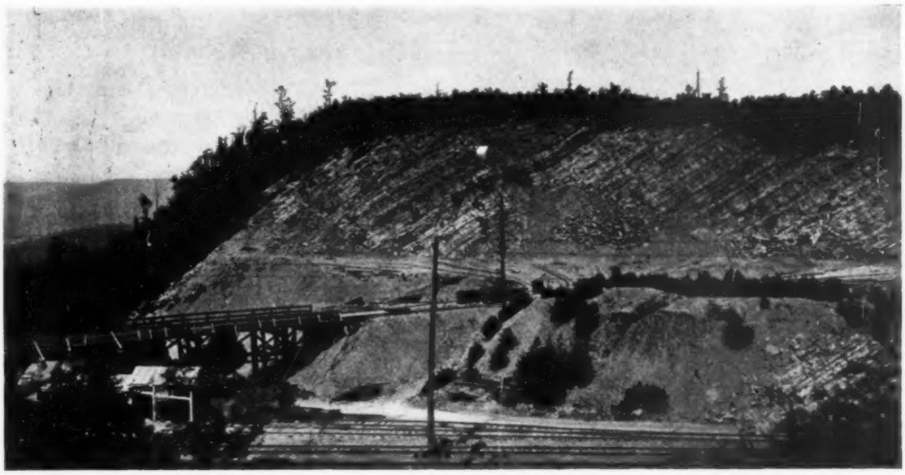
Who can describe our amazement when my first blow brought out a beautiful head of a new eurypterid, nearly three inches wide (later described by me as *Pterygotus inexpectans*). It was the first of that formation. Miss Winifred Goldring of the State Museum staff later obtained three more specimens, two of which were very young growth-stages.

On that same trip, the seeds of the Gilboa trees were found, and that also is illustrative of the romance of collecting. Shortly before, I had seen figures of Carboniferous seed ferns with seeds described by David White, and had learned from Miss Goldring that Professor Johnson, of Dublin, had predicted Devonian seeds. So I thought I might look for them in the Devonian plant beds at Gilboa, but no promising black shale could be found.

One night, as we were trying our luck at fishing in the Schoharie Creek, both my companions went out on a big bowlder in the river while I



ONE OF THE STRANGE EURYPTERIDS, *STYLONURUS CESTROTUS* CLARKE, FROM OTISVILLE, ORANGE COUNTY, NEW YORK



The quarry at Otisville, where the eurypterids were found

remained on shore to enjoy the beautiful scenery of the Manorkill Falls just behind us. While I was sitting there, I noticed a large slab of black shale sticking out of the river sand. It was covered with beautiful clusters of fern seeds. I seized it, and yelled to the fishermen. We carried the precious slab home. When we arrived, my companions discovered they had left their pipes and tobacco on the bowlder and blamed me for having made too much "fuss" over my find. But it was worth it, for these are the oldest seeds known at present. There was no doubt that the bed from which the slab came was near by, and we found it the next morning not a hundred feet away at the foot of the cliff in the corner between the Manorkill and Schoharie creeks. From it we secured a fine collection of seeds. Miss Goldring went out later and obtained the spore-bearing organs, the foliage and rootlets. The locality will be lost to science when the reservoir is filled.

Sometimes fossils will turn up just as the collector is ready to "quit." Dana D. Luther and I were sent out to collect Guelph fossils and facts on the Guelph stratigraphy after Doctor Arey had obtained a fine collection of Guelph fossils, the first in New York State, in the sewer trenches of the city of Rochester. We had wandered for a week between Rochester and Lockport over a belt where the Guelph ought to be, without seeing a trace of outcrops or fossils, except a few specimens from loose blocks too poor to prove anything. One Saturday afternoon as we plodded back to Shelby, we decided to quit the hopeless job. We walked along a canal feeder and came north of the belt of supposed Guelph into a stretch of woods, where we were greeted by house-high piles of dolomite taken out of the canal feeder. The fresh Lockport dolomite is not a promising field, so we passed indifferently between the piles, but we stopped simultaneously with cries of amazement. All around us were the most beautiful *Monomerellas*, *Tremanotus*, and other Guelph fossils sticking out of the blocks. We could scarcely believe our eyes, but there was no doubt that here was a wonderful Guelph fauna, although it appeared at a horizon lower than that we had

The Manorkill Falls, Gilboa, New York. The seed locality is at the right

Two slabs with clusters of seeds from Gilboa, New York

searched. It was the "Lower Shelby fauna" of Clarke and Ruedemann (Memoir 5). The next morning found both of us at those rock piles of tough dolomite; and many days thereafter we returned to the village inn, happy as crickets, with blistered hands and heavy loads, but feeling rich and filled with expectation of what the next day would bring. And so well was the locality hidden in the woods that a certain palæontologist, who wished to get ahead of us in publishing the Guelph fauna and to whom I had foolishly shown my material, rode back and forth on his bicycle between Rochester and Lockport several times without finding the place.

Certain groups of fossils have always been considered aristocrats. They do not mingle with the common horde of brachiopods, bryozoans, or mollusks, but prefer to remain by themselves in dignified reserve and grow in plantations. Such aristocrats are the eurypterids, crinoids, graptolites, and especially the sponges. That New York State has afforded the finest collections of Palæozoic sponges in the world, is made evident by the memoir of Hall and Clarke, and by the exhibit in the State Museum. It is no wonder, then, that sponge-hunting in the upper Devonian rocks of the middle central and southwestern counties early became a fine art among certain members of the staff and several local collectors. Stories of these sponge-hunting expeditions, when Hall's son "Jim" was the leader, were still current among the older men when I came to the New York Survey, and are still told by Jacob Van Deloo, son of Hall's veteran collector, C. A. Van Deloo. Many weird objects were sent to Albany by these collectors as sponges, but that was in the "good old prohibition days." The elder Van Deloo was an untiring collector, whom Hall considered the best he ever had. He would not stop until he had cleaned out a locality, and would lug the material for days if necessary, on his back. In 1869, with C. A. White, he cleaned out the Vincent crinoid plantation in western New York so completely that it is said no other specimens have since been found there.

Neither Hall nor Clarke had interest in the faunas of the eastern shale belt. Hall left that region severely alone after the acrimonious Taconic controversy, and Clarke was primarily interested in the Devonian faunas of western New York, where his friend Luther supplied him with ever new material. No wonder, then, that I could discover hitherto unknown faunas on Rysedorph Hill that for more than fifty years had been in full view of the office windows of Hall and Clarke.

On the top of that hill a conglomerate outcrops, and the west side is strewn with pebbles. While climbing that side, I picked up a beautiful shell of the brachiopod *Christiania* which showed the interior structure perfectly. Because only one species (occurring in Tennessee) was known in America, Doctor Clarke was skeptical when I told him of this specimen, but one glance convinced him. The fauna of the conglomerate within view of Albany furnished more than eighty species, nearly one third of them new and containing seven new trilobites. Some of the latter belong to genera not before noted on this continent and indicating an Atlantic element in the fauna. This interesting conglomerate not only contains faunas ranging from lower Cambrian to the Black River and Trenton formations, but it has also yielded faunas that had not been

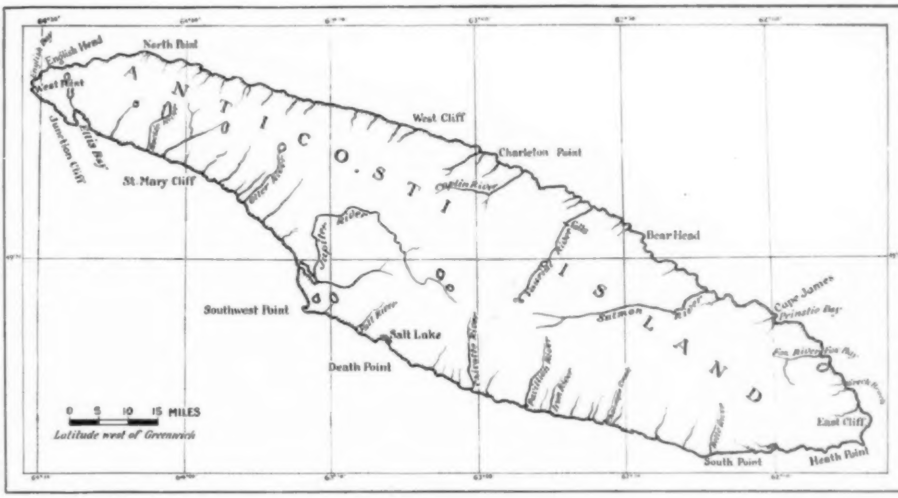
observed before, and that belong to assemblages now hidden or obscured in the metamorphosed limestones of western Massachusetts but which were partially discovered later in the Chambersburg limestone of Pennsylvania and in Virginia and Alabama.

Sometimes fossils actually seem to press themselves upon one's notice. Miss Goldring lost her hold one day and slid down over a slanting cliff. Something stung her on that rapid journey, and when she looked for the offending party, it was a fossil starfish,—the only starfish known from the Gaspé beds. I have just described it and properly named it "Goldringæ."

On the other hand, when two collectors, each interested in a different subject, go to the field together, it often happens that the fossils are discovered by the disinterested individual. Thus when I was with Doctor Ulrich to collect in the Clinton formation at Clinton, he picked up a beautiful new *Dendrograptus* which I felt I should have, and I found a complete *Dalmanites* which was of interest to him. We exchanged our finds, but unfortunately Doctor Ulrich lost his share of the deal, and he still, with grave suspicions, asks me the whereabouts of that trilobite.

As a warning against over-enthusiastic collecting, I will close with a little experience of my lamented friend Gilbert Van Ingen. While still working with the New York Survey, "Van" walked one rainy day through the main street of Granville, New York. On the wet sidewalk he noticed many fine specimens of the Cambrian jellyfish *Dactyloidites bulbosus*, and, although he was to return that day to Albany, he set out enthusiastically to procure some slabs. He sought the manager of the quarry and asked him to take up some of the slabs and replace them with new ones. The manager kindly agreed and asked him to mark the desired slabs. So "Van" marked the slabs with a red cross and went home. Within a week or two a letter announced that a freight car loaded with the whole sidewalk of the main street was ready for shipment and that the bill was $600. Doctor Clarke had neither funds nor inclination to meet the expense and the wires were kept hot that day between the perspiring Gilbert Van Ingen and the kind manager. It happened that "Van" had put the paint and brush behind a near-by barn before leaving, and a little boy who had watched him had continued the job of marking the sidewalk.

The few experiences I have mentioned tend to show that even in the well-searched State of New York many surprises still await the enthusiastic collector, and that there is no lack of romance in the field work at home as well as abroad. It is true that the "kick" coming from the element of danger in foreign countries is lacking, only an ill-tempered bull, or dog, or farmer causing a little excitement at times, especially if one is out with a high-strung, independent companion. Then the unexpected may happen at any time. But what could replace the pure joy with which the collector sits down when he has made a good find, lights his pipe, and gloats over the new discovery! And in the fall, when fool game-hunters overrun the woods, there may even be an element of real danger, as for instance, when a reckless idiot mistakes the collector, who is in a stooping position, for a fox or something, and fires away. This once happened to me at the East Canada creek.



Sketch map of Anticosti Island

Hunting Fossils on Anticosti Island

By W. H. TWENHOFEL
Professor of Geology, University of Wisconsin

FOREWORD.—THE recorded history of Anticosti extends back nearly four hundred years. It was discovered in 1534 by Jacques Cartier, who named it Isle de l'Assomption. At that time no people made the island their permanent home. It was visited each spring by the Montagnais Indians from the north mainland, who came there for hunting. They called the island "Natiskuan." Their last trip is said to have been made in May, 1882. Formerly, the Esquimos lived on the north mainland, but about 1600 the Indians defeated them in a great battle, and drove them to the east. It is possible that before their defeat, the Esquimos visited Anticosti. I camped one night on this old battlefield, a most ghostly place.

The island was granted to Louis Joliette in 1690. At that time it was known as "Anticosty"; the origin of the name is unknown. Until shortly after 1700, the descendants of Joliette lived on the island, but from that time until 1895, when it was purchased by Henri Menier, no Joliettes lived there. During this period of more than a century and a half the island was a rendezvous for smugglers, wreckers, and others of questionable occupation. Stories are still current among the fishermen of ships lured to the coast by means of lights suitably placed. One of the most famous smugglers was Louis Olivier Gamache, who came to Anticosti in 1810, and made his home at Gamache, now Ellis Bay. Many interesting tales are told of this man. It was supposed that he had Satan as an aid, and could make the winds and sea obey his will.

INTRODUCTION

EVERY ship that enters Canada by way of the great St. Lawrence passes by Anticosti Island. If passage be by the North Channel, the passengers will see the balsam- and spruce-crowned cliffs of the north coast; if by the South Channel, they will see the exquisite beauty of the moss-covered and lake-studded terraces of the south side of the island.

The island, for all its natural beauty, is not loved by the older sailors. They remember too many comrades who have lost their lives on its treacherous shores. In the old days of sailing ships, never a storm occurred which did not take its harvest of ships. The place is known among seamen as the

A view typical of the north side of the island. Cliffs of Tower Point and Bear Head each about 300 feet high

"cemetery of ships"; there is hardly a mile of shore which does not tell a tale of disaster and death in timbers and iron half buried in the sand and in the graves of unfortunate sailors.

CHARACTER OF THE SHORE AND SURFACE

The north coast of Anticosti is largely a succession of bold headlands of which many rise 200 to 300 feet directly from the sea. Between the headlands are small bays most of which are bordered by narrow strips of low land. On the south coast high headlands are not common, except on the extreme east end and from South to Southwest Point, where considerable stretches of the coast are cliffed. Few of the cliffs of the south coast exceed 25 feet in height and most of those which are higher than 25 feet are composed of unconsolidated sands and sandy clays. The bays of the south coast are generally bordered by considerable areas of low land. Nearly every bay on the island has a stream flowing into it and some have several. Near the coast the valleys may be several times wider than the streams, but inland they become narrow and terminate in cañons. Every stream is a succession of rapids and falls with an occasional deep pool, the latter abounding in trout and salmon. The largest fall is on Vaurial River. This is about eight miles from the sea and is about 130 feet high.

The island is terraced, with the widest terraces on the south side where some are several miles wide. On the north side several terraces may be seen on almost every headland. The highest land of the island is near the north coast, and does not much exceed 400 to 450 feet in height.

Lakes abound, and they occur at all observed elevations. Beavers are responsible for some; many are developed marginal to the sea through the building of littoral barriers. This is particularly the case on the south coast. Most of the barrier lakes contain fresh water; others rise and fall with the tide, and at low water some of the latter are very shallow. An amusing incident arose in connection with one of these. At one of the 1919 expedition camps, the two boys on cook duty for the day made some cornstarch pudding and set it in an adjacent small shallow lake to cool. At dinner-time, the tide was high, and one of the boys, on going

after the pudding, found it under several feet of water.

CHARACTER OF THE ROCKS AND THE GEOLOGIC SECTION

The rocks of Anticosti consist of limestone, shale, and sandstone; important in the order named. The strata have southwesterly inclination of from 70 to 90 feet to the mile. As a consequence, the younger rock of Anticosti forms the south coast and the older the north. The thickness is about 2500 feet. These strata were deposited in an ancient embayment which was in existence in the Cambrian, Ordovician, Silurian, Devonian, and perhaps the Mississippian period. The oldest strata of the island are of Richmond, or late Ordovician age, and the youngest are early Niagaran, or middle Silurian age. The strata have been placed in seven formations which with their thicknesses are as follows:

ORDOVICIAN	
Richmondian series	
English Head formation	229 feet
Vaurial formation	600 to 700 feet
Gamachian series	
Ellis Bay formation	190 to 256 feet
SILURIAN	
Anticostian series	
Becsie formation	200 feet
Gun River formation	400 feet
Niagaran series	
Jupiter formation	620 feet
Chicotte formation	73 feet

A stratigraphic break occurs between the Ordovician and Silurian strata. This is not apparent in the structure, but is shown in the decided evidence of water shallowing, the presence of large rock fragments in the

Vaurial Falls. Because of the dryness the volume of water is scant. A small tributary is shown on the right

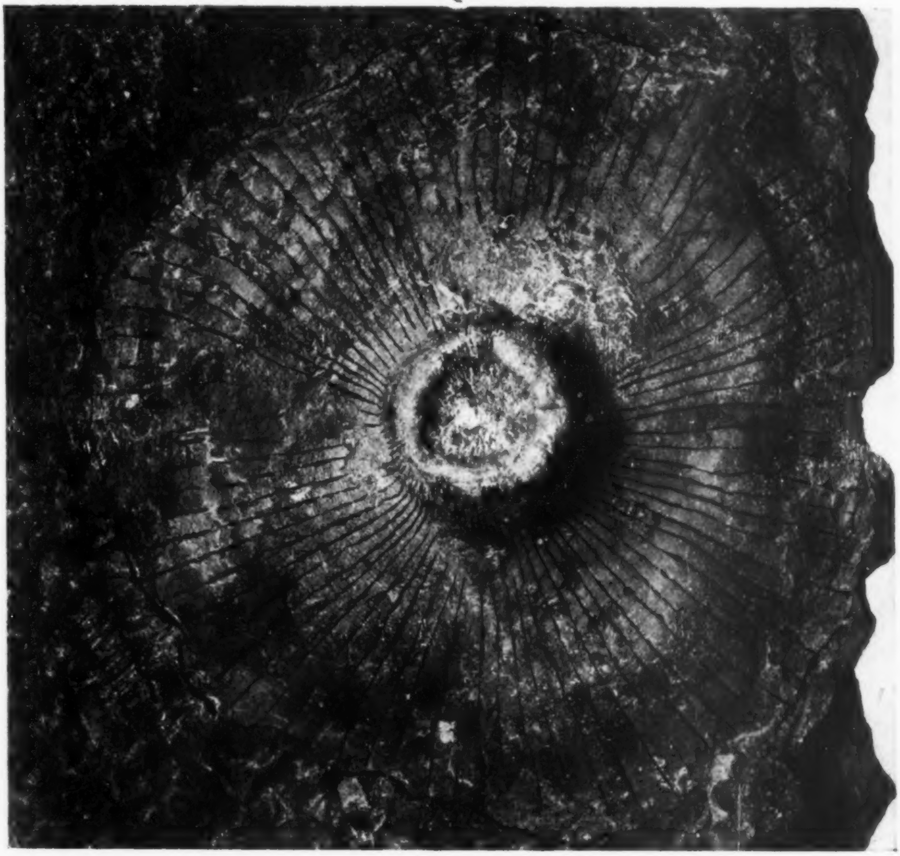
Portion of a slab covered with shells, fragments, and pebbles. It contains a small colony of a peculiar variation of Halysites. Natural size

basal Silurian, and the marked change in the fauna. It is not known that a land interval intervened in this region between the deposition of the Ordovician and the Silurian, but it is certain that the bottom of the sea was brought above the profile of equilibrium so that deposition was arrested, and the bottom probably underwent some erosion.

FOSSILS IN THE ANTICOSTI ROCKS

The rocks of Anticosti abound in fossils, the majority of which are splendidly preserved. The abundance of the shells of some species borders on the marvelous. A brachiopod known as *Parastrophia reversa*, found in the Ellis Bay formation, is almost unbelievably abundant, and the brachiopod *Atrypa reticularis*, in some Silurian horizons, is nearly as plentiful. Coral reef limestones exist in both the Ordovician and Silurian strata, the oldest reef being near the top of the Ordovician. This reef is less than ten feet thick, but it has great lateral extent, having been seen at points more than 75 miles apart. The youngest reef is in the Chicotte formation in which there are places where the coral reef limestones rise 15 to 20 feet into the overlying strata. The oddest coral found in the rocks of the island is known as *Beatricia.* This resembled unbranched trees and stood upright on the sea bottom, attaining heights of more than a dozen feet with diameters at the base up to a foot. The trunks now lie prostrate in the sediments and resemble logs embedded in cement. *Beatricia* is found in both the Vaurial and Ellis Bay formations and may be seen in great abundance in Ellis Bay, at Cape James, and at West Point.

Beatrica noduloso, distal end, one half natural size. Cape James, Ellis Bay formation. This coral stood vertical on the sea bottom and reached a maximum height of 12 or more feet



Top surface of *Chonophyllum canadense*, one of the rugose corals locally common in the Chicotte formation, Jumpers. Natural size.

Excellent places to obtain an abundance of fossils from the English Head formation may be found at English Head and Macasty and Charleton points; from the Vaurial formation at Vaurial, Oil and McDonald rivers, Battery Point and Observation Cliff; from the Ellis Bay formation at Ellis and Prinstie bays, Junction Cliff and head of Vaurial River; from the Becsie formation at Becsie River, Reef Point and Wreck Beach; from the Gun River formation at Gun River and near Cape Sand Top; from the Jupiter formation at East Cliff, Pavilion, Belle and Jupiter rivers and the Jumpers; and from the Chicotte formation at Death and South west points and Chicotte River.

EXPLORING ANTICOSTI ISLAND

I first visited Anticosti Island in the summer of 1909 and made the trip around the island, using a codfish schooner manned by two French Canadians, Mr. Selas Poirer and his son Edmond. The trip required nearly two months, and was unsatisfactory because the coast could be approached only where small harbors permitted the schooner to land and remain. There was also much rainfall that summer, and black flies and mosquitoes were so abundant at times that work in the open was hardly endurable. The result of this summer's work was a large collection of fossils which, however, represented only those parts of the

sequence that had exposures adjacent to the places where landing was possible. A clear understanding of the stratigraphy was not attained. This expedition showed that a complete study of the stratigraphy required boats small enough to move in the shallow waters which margin most parts of the island.

A second expedition to explore Anticosti was made possible in 1919, and it was decided to attempt the study of its coasts by using the boats known as dories. These boats are clumsy and heavy, but are extremely seaworthy. Six students, Messrs. R. H. Bennett, W. H. Conine, W. J. Hamblin, Carl Hoppert, L. L. Pfrang, and Chester Rieck were members of the expedition. Three dories were obtained from Mr. George Martin-Zédé of the island's management.[1] These were rowed by the boys while I walked the beach all the way around. As the island is about 135 miles long and 35 miles wide, it is estimated that the boys rowed about 400 miles and that I walked between 600 and 700 miles. Ascent was made of Oil, McDonald, Vaurial, Salmon, Jupiter, and Gun rivers. Nearly every foot of the shore was seen; the exceptions being where high cliffs had deep water at their bases. The summer was dry, and black flies and mosquitoes were scarce, the weather was so fine at several of the camps that tents were not erected and we lived in the open both day and night.

The expedition started from Ellis Bay on the south side near the west end, preceded westward around West Point, thence eastward along the north coast to East Cliff, and westward to Ellis Bay. About two months were required for the trip.

[1]Mr. George Martin-Zédé is a great personal friend of the owner of Anticosti, Mr. Gaston Menier, and he annually visits Anticosti. He afforded every possible facility to make the exploration of Anticosti possible.

One half of the provisions was loaded in the dories at the start; the other half was shipped to Heath Point, a few miles from the east end. For fresh meat we depended on game and fish. Collections were left at each lighthouse as we passed.

The work of each day was full of interest and hardly a day passed that something did not occur to create excitement or amusement. On the morning of starting, Thursday, July 17, the waves were breaking on the edge of the reef, and it was very foggy. The boats started early in the morning while the tide was high. I walked along the beach studying the cliffs. From time to time I heard the oars as they worked in the crude oarlocks, but in about an hour I ceased to hear them and I assumed that the boats had gone ahead. At noon, Bennett and Pfrang came along and informed me that their boat was aground on the reef about a mile from the shore and about two miles back. I went back with them, gave them directions, and returned to find the other boys. I found them at Strawberry Cove, just west of the famous locality of Junction Cliff. Hoppert and Conine's boat came ashore first as they had become seasick and when they were found by Hamblin and Rieck both were sound asleep on the sands. Hoppert was in the navy during the war, and afterward, when the boys called him "The Old Salt," they invited an explosion.

A few days later English Bay was crossed, the start being made from West Point. For about a mile in the lee of West Point the rowing was in quiet water on the reef and on the west side of the bay. On the east side of the bay was a line of breakers; the waves breaking, recovering and then rushing across the reef at great speed toward

English Head. Pfrang had never had a boat on the sea before this trip, and when he saw a big roller coming he would forget he had oars and follow the wave with his eyes to see what it would do. Had the boats been other than seaworthy dories, they might have been swamped at this place. As soon as English Head was passed, the water was smooth.

English Head is a famous locality for fossils of the English Head formation, and in a small brook on its west side may be seen an outcrop of the "Track Bed," a bed which has been traced for seventy-five miles on the north coast and which is thickly covered with markings consisting of double rows of cylindrical pits. These have been supposed to be tracks of crustaceans. No remains of an organism capable of making these impressions have been found in the Anticosti rocks.

The expedition moved along the north coast at a rate of from 4 to 5 miles each day. Camp was not moved every day and on some days 15 or more miles were made. The cliffs expose the geology in a wonderful way and reveal as in an open book the sequence of events which took place in the seas in which the Anticosti sediments were deposited. Nearly every exposure yielded a large collection of brachiopods, trilobites, corals, and other fossils, and it was not long before the transportation of the collections became a serious problem.

The scenery of this coast is wild and picturesque. Hundreds of gulls swarm about the high cliffs which tower above the beach. Following the bases of the cliffs was not always pleasant. Gulls and other birds dislodged rocks from the cliffs and these tumbled to the sands or water below. At high tide, water washed the bases of the cliffs and this made it difficult to get around them. This was not so bad in the daytime, but several times, as was the

A portion of the "Track Bed," English Bay

case at West Cliff, this had to be done at night. Wading in water above one's knees, with an occasional wave rolling in heavy enough nearly to swing one from his feet, and hearing the occasional rocks falling with a splash into the near-by water, gave one a strong wish to be elsewhere.

The expedition reached the mouth of Vaurial River on July 31, and on August 2 Rieck, Hamblin, and I began the study of the river section and the making of a plane table and alidade survey of the river's grade and course. Pfrang and Hoppert assisted on the first day of this work. We slept on the night of August 2 in Vaurial cañon and the following day the rest of the party came up to see the falls. By the evening of August 3 we had reached the falls, retraced our steps to get out of the cañon, climbed the cliffs, and ascended the river for a mile above the falls. The following day we ascended the river to where, at an elevation of over

350 feet, the beaver dams change it into a series of lakes. For a part of its course above the falls the water flows underground. We returned to camp on August 4, reaching it before midnight. Some splendid fossils were obtained from the Vaurial River section.

The expedition reached Salmon River on August 7. Here, the boys caught several big salmon and we obtained a large collection of fossils from Battery Point. The rocks of Battery Point are filled with prostrate trunks of *Beatricia* and as these ordinarily project from the cliff face a few inches and many are hollow, they resemble cannons projecting through the walls of a fort. This accounts for the name Battery Point.

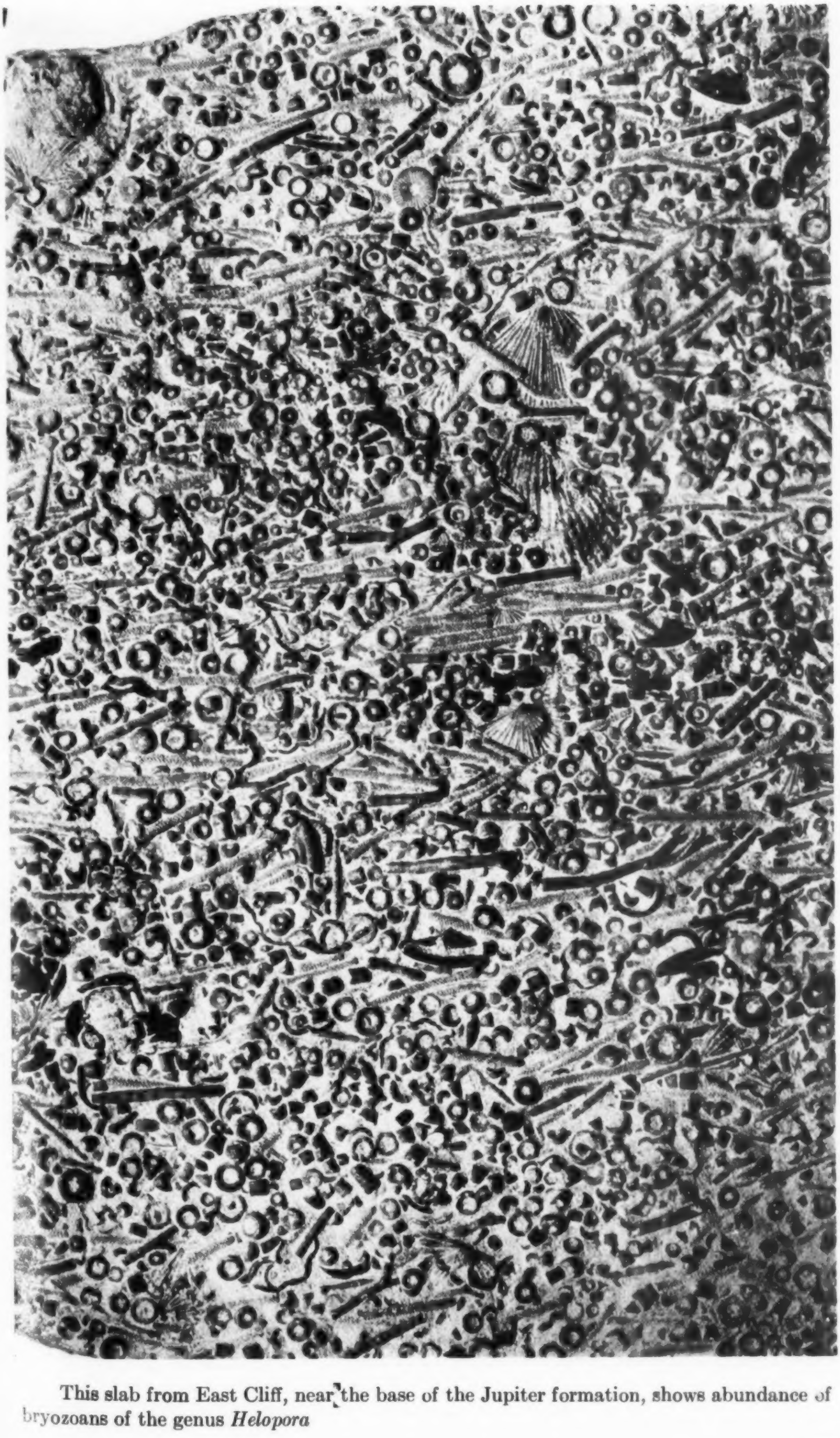
Fox Bay was reached on August 12. The base of the Becsie formation is exposed on Fox Point on the west side of the bay and Reef Point on the east side is entirely composed of Becsie strata. Reef Points is the best locality known from which to obtain the beautiful fan-shaped bryozoan, *Phænopora superba*.

East Cliff was rounded on August 14 and the worst part of the journey was over, as there are three lighthouses, two telegraph stations, and many game warden camps on the low south coast. East Cliff is about one hundred feet high and faces the sea to the east with an extremely forbidding aspect. Its base is an ancient Silurian coral reef which extends seaward as a reef and submerged rocks.

East Cliff is a splendid locality from which to obtain basal Jupiter fossils. Corals of several species may be collected in unlimited quantity, while from the overlying shales slabs covered with an abundance of bryozoa and small brachiopods may be obtained. Free specimens of the trilobites *Calymene niagarensis* and *Phacopidella orestes* are common, and there is an abundance of the brachiopods *Atrypa reticularis, Eospirifer radiatus* and *Cœlospira hemispherica*. One can readily obtain from 30 to 40 species of fossils in the course of an hour's collecting.

Iron River was reached on August 25 and there we made what was probably the most attractive camp of the expedition. The tent was erected on top of the cliff, and cooking and eating were done beneath the overhanging cliff. The cliffs of Iron River and the adjacent coast are abundantly filled with fossils of the upper portion of the Jupiter formation.

We left Iron River on August 27. The weather did not promise a great deal, but I left on foot immediately after breakfast with directions for the boats to come when the wind changed. Pavillion River was to be the objective. I reached Pavillion River by two in the afternoon. I had not seen the boats all day. About four o'clock I started back and had retraced 6 miles of the journey, when the three boats came in sight about a half mile from shore. Just before I saw them I had shot a deer, so Rieck and Hamblin came ashore to take it into their dory. By the time this was done the other boats were out of sight and the water was beginning to get rough. Rieck and Hamblin shoved off. I walked along the beach at the mouth of Pavillion River. The other boats were not in sight and as it was dark I lighted a fire for a signal. Rieck and Hamblin finally appeared but were unable to reach shore because of the heavy sea and shallow water. However, they jumped into the water and I waded out to meet them. In this way we were able to bring the boat ashore. That night we slept on the sands and the



This slab from East Cliff, near the base of the Jupiter formation, shows abundance of bryozoans of the genus *Helopora*

The mouth of Iron River

next morning found that the other members of the party had passed the mouth of the river in the dark and had spent the night about a mile beyond.

The top of the Jupiter formation is exposed in the cliffs a short distance up Pavillion River and in another cliff three miles west of the mouth. It is doubtful if there are more fossiliferous strata in the Anticosti section than those of the upper twenty-five feet of the Jupiter formation. It is no trouble at all to collect a handful of beautifully preserved trilobites and a bushel of splendid brachiopods. Corals are also extremely abundant. The surfaces of the thin limestones are literally jammed with small shells and tests of brachiopods and ostracods, together with zoaria of bryozoa.

Ellis Bay was reached on September 11. The 1919 expedition was a success. The complete section was seen, not once, but several times, and the collections consisted of about two tons of excellent fossils, representing more than 400 species.

The Fossil Birds of North America

By ALEXANDER WETMORE
Assistant Secretary, Smithsonian Institution

THOUGH Emmons in 1857 described what is supposed to be a fossil bird from fragmentary bones from North Carolina, study of the bird life in the fossil deposits of North America may be said to begin properly in the year 1870, with the announcement by O. C. Marsh of five forms from the Cretaceous, and four from what were then called Tertiary formations. Others were recorded at once by Cope, while in 1872—from Marsh again—came notice of the first of the famous Odontornithes, the toothed birds of the Cretaceous beds of the west. The labors of the two eminent palæontologists mentioned continued to such good effect that in 1884 the list of described fossil birds had increased to 46 species. A number of others were added from various sources during the succeeding decade.

Exploration of Pleistocene beds, in what are known as the Fossil Lake deposits in Oregon, led to the discovery of large numbers of bones of birds, from which R. W. Shufeldt in 1891 and 1892 identified more than fifty species, including flamingoes, gulls, coots, grouse, eagles, a crow, and a blackbird among extinct species, and bones of the mallard, baldpate, hooded merganser, and many others among living forms.

Though rich in avian material the Fossil Lake beds have been eclipsed by discovery of the wonderful deposits in the asphalt lenses of Rancho-la-Brea near Los Angeles, California, which constitute one of the most important finds in this branch of palæontology on this continent, since they have yielded approximately 100,000 bones of birds. These have passed under the capable hands of L. H. Miller, who has found among them extinct and modern species of eagles and condors, a great heavy-beaked vulture (*Teratornis merriami*) a large gallinaceous bird, owls, storks, and many others. Knowledge of the Pleistocene avifauna of California has been supplemented by additional forms from asphalt deposits near McKittrick, and by bones taken from Shasta, Samwel and Hawver caves in northern California.

Between the birds of the Cretaceous and those of the Pleistocene that have just been mentioned intervene many interesting forms. Among those recorded from the Tertiary of North America, one of the strangest is the huge *Diatryma steini* named by Matthew and Granger in 1917 from a skeleton nearly complete, secured in the Eocene of the bad lands of Wyoming. This great creature, though not as tall as an ostrich, was heavier in body, with a massive head and neck and a compressed bill of tremendous size. Among the few other Eocene birds known, may be mentioned an owl-like form (*Minerva saurodosis*) and species resembling auks and avocets which have been described recently by Wetmore.

Forms of birds of the Miocene and Pliocene seem to have been similar in general appearance to those of today. From the diatomaceous beds

of this age near Lompoc, California, Loye Miller has named shearwaters, boobies, auklets, and godwits closely allied to living forms. Explorations by parties of the American Museum in the deposits of Sioux County, Nebraska, supplemented by material secured by Mr. Harold Cook, and by Princeton University and the Carnegie Museum, have brought to light an interesting avifauna from the Miocene and Pliocene in which the present writer has identified hawks and eagles, a chachalaca, a limpkin, and a paroquet. In addition, from deposits in southern Arizona, recorded as of late Pliocene age, he has found a tiny goose, no larger than a duck, a tree-duck, some shorebirds, and fragments of an ocellated turkey, a bird that lives today in hot lowland jungles from Campeche south into Péten. With mention of J. A. Allen, F. A. Lucas, and C. R. Eastman, the list of those who have worked with our avian fossils is practically complete.

Continued investigations on the part of a number of institutions bring to light occasional bones of birds, usually of forms previously unknown, while there are still to be fully exploited Pleistocene and Recent cavern and fissure deposits. The present writer has identified a number of birds not previously known from midden and cave deposits in the Greater Antilles, among which a flightless land rail and a giant barn owl may be cited as perhaps the most interesting. That valuable data are to be obtained from careful study of such deposits is easily seen when we consider the results secured recently in Europe by Želízko in southern Bohemia, by Lambrecht in Hungary, and E. T. Newton in England and Crete, to mention only a few of those interested in such material.

At the present time the writer is engaged in revision of the fossil list from North America, for inclusion in a fourth edition of the official check-list of birds of the American Ornithologists' Union, from data that he has assembled for general work on this subject. The material at his command he believes to be more complete than that previously available to workers in the subject. The fossil list, exclusive of the West Indies, now contains approximately 150 species, while 100 additional forms of birds still found living have been secured from the Pleistocene.

In conclusion, attention is called to a further project dealing with avian fossils. Though students of this subject are often hampered by scanty material, they are fortunate in that their specimens are of such nature that reproductions may be made in plaster. Skilfully prepared, these are identical with the original and serve as well for study. Theodore S. Palmer, the energetic secretary of the American Ornithologists' Union, has been instrumental in organizing the project of having casts prepared of all types of fossil birds, so that they may be deposited in the principal museums of this country. When complete sets are finally available, there should result increasing interest in the subject of fossil birds.

Important Results of the Central Asiatic Expeditions

In far off Mongolia the Central Asiatic Expeditions of the American Museum of Natural History, under the leadership of Dr. Roy Chapman Andrews, are finding many a romance of former life hidden away in the Desert of Gobi. The region is a great interior basin surrounded by high mountains with all the drainage inland. Granite and greywacke rocks come to the surface and extend in every direction for great distances, but here and there the prevailingly level stretches are broken either by ravines, cliffs, escarpments, peaks, or basalt dikes. Small sediment basins also occur. These sediment basins are of vital interest in the present connection, for it is in the sedimentary and æolian deposits of former ages that the remarkable fossil finds are being made. The present abundant life that roams these great plains seeks the water holes, swamps, and intermittent lakes, as did the animals of the past.

In the following pages six members of the organization, Prof. Charles P. Berkey, and Frederick K. Morris, geologists, Major L. B. Roberts, topographer, Dr. R. W. Chaney, palæobotanist, and Dr. W. D. Matthew and Walter Granger, palæontologists, review briefly the most important finds in their respective fields.—Editor.

The Geological Background of Fossil Hunting in Mongolia

By CHARLES P. BERKEY AND FREDERICK K. MORRIS

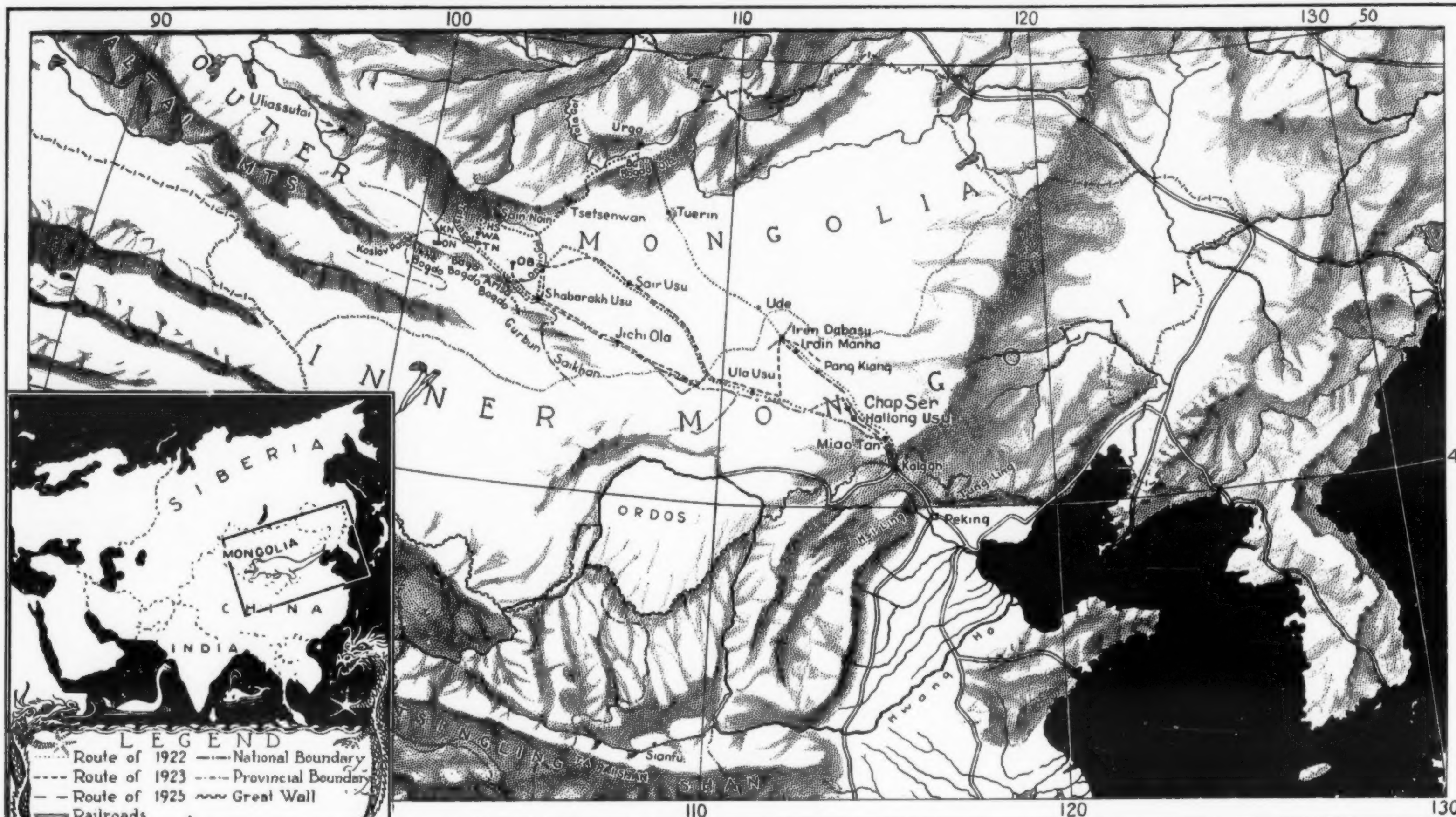
The geologist's part in the romance of fossil hunting lies in reading contemporary history, piecing it together from the fragmentary evidence of the rocks that preserve both the fossils and the record. It is his task to find out what kind of a world it was in their time, and what has happened since, in the conviction that an interpretation of the physical conditions will be helpful both in leading to discoveries and in understanding them. All sorts of evidence are grist to his mill—rocks, fossils, structures, and surface features. Among his other activities, therefore, he is an inveterate fossil hunter. In this field the geologist works with the palæontologist to the same end.

Fossils could be found, of course, by any one who is willing to look for them. They could be collected by any one who would pick them up, and they could be classified by any one who would name and compare them. But all this might be done without greatly enriching our understanding. Collecting must be done in an orderly way, so that we know exactly from what stratum each bone came. Specimens so collected come to have a meaning in the succession of organisms and in the order of events, and take their place in science. Both geologist and palæontologist justly claim them.

The kinds of fossils found in the strata deposited in succession from earlier to later time differ in so orderly a manner over the whole earth that by means of them age may be determined. Thus, the organisms of a particular time whose remains lie buried in the rocks become distinguishing criteria in identification and age of strata.

When and how did Mongolia begin to accumulate fossil-bearing strata?

In the middle of the Age of Reptiles, Mongolia was uplifted into chains of rugged mountains. During the first few million years after the uplift, the mountains were worn down by the work of winds, frosts, and water, until the whole region became a nearly level surface.



MAP OF CENTRAL ASIA

Fig. 1—The mountains are shaded as though the light were falling from the upper left-hand corner, while the basins are left white. The mountain rim enclosing the Mongolian basin shuts out moisture so that the climate is dry and therefore almost none of the rivers reach the sea. During past ages such inland-flowing rivers have carried down to the center of the basin, the sediments in which the fossils are found

Then the central portion of this low, nearly level country was lifted and warped into the form of a gigantic shallow basin, a million square miles older rocks (Fig. 2). It is only in this new series, belonging far up in the geologic column, that the great fossil fields of Mongolia have been found.

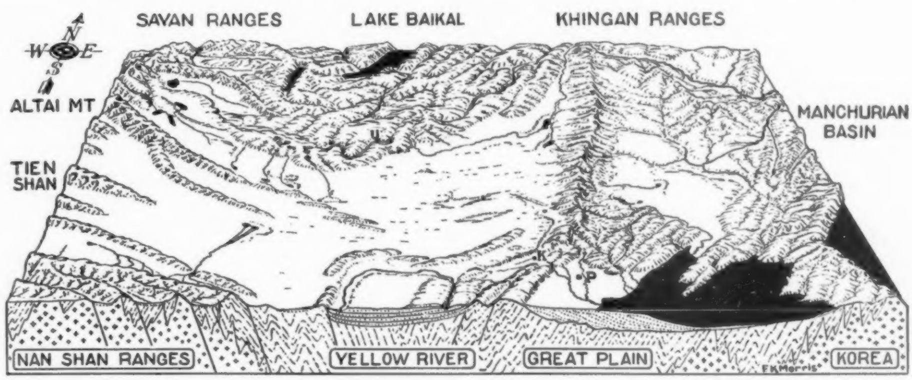


Fig. 2.—Perspective sketch of Mongolia and Manchuria. The drawing represents a block cut out of the earth's crust, showing the structure of the rock formations along the cut edge. Both countries are shallow basins surrounded by mountains. The basins are separated by the Great Khingan Range, whose steeper slope is toward the east. The sediments which have washed into the Mongolian basin in late geologic time contain the fossils of creatures which lived there while the sediments were being deposited. The letters P, K, U, stand for Peking, Kalgan, and Urga respectively

in area (Fig. 1.) The winds that swept across the continent dropped their moisture on the uplifted rim, and the rains that fell within the rim drained toward the interior. The inland-flowing rivers washed gravel, sand, and mud down from the highland margins and laid them out in thin sheets of sediment on the floor of the basin (Fig. 2.) These same rivers were the original gatherers of specimens, for we now find stems of plants and bones of animals enclosed in the muds which they deposited. It must have taken millions of years to assemble all this material from which were selected, in three short seasons, the collections brought back by the Expedition.

The contrast between these sediments and the rocks of the floor on which they lie is the most striking fact in Mongolian geology. The crumpled old rocks of the floor are remnants of the worn out mountains, and the overlying sediments are the beginning of a new series of strata, reposing on the upturned edges of the

All the largest mountain systems of Asia, even the Himalayas, have risen since the Mongolian basin was formed, and therefore are younger than some of these fossil remains. Growth of the continent to larger size and the building of new mountain systems have profoundly affected the rainfall, the temperature, soils and drainage, and thus have presented a changing environment in which plants and animals struggled for a chance to live.

The earliest sediments within the basin indicate a wetter climate than the present. Black muds were spread out in broad shallow lakes, forming layers as thin as paper, where fossil fishes, mosquitoes, May flies and caddis worms, are preserved as delicately as flowers pressed in a book (Figs. 3 and 4). They indicate an environment that exactly suited the huge, swamp-loving dinosaurs that belong to that time. But long ago, even during the Age of Reptiles, the climate began to change It must have become comparatively arid, for it is clear that the dinosaur

Fig. 3.—The larva of a giant May fly, almost natural size

eggs were laid in the sands of a semi-desert (Fig 4). All through the Age of Mammals, which followed, the rainfall was light and variable, but the withering rivers continued to deposit irregular strata of gravel, sand, and clay. Corresponding to this environment, we now know that there were many ranging types of animal life, like the titanothere and the giant *Baluchitherium*, together with small burrowing animals which lived much as prairie dogs do now in modern semi-deserts.

The last renewal of rainier conditions came in the great Ice Age, when there were cycles of wet, cold climate alternating with others that were warm and arid. In the wet cycles, lakes were enlarged, and rivers eroded the now abandoned valleys. In each arid cycle, which doubtless lasted for many thousands of years, their work of erosion was checked, and sediments clogged their courses. Thus it came about that this elevated interior basin, with its great stretches of steppe

Fig. 4.—Fossil "mosquitoes" from the Gobi Desert. They are not ancestral to our modern mosquitoes, but belong to a related family of *Chironomidæ*. They were contemporary with the largest dinosaurs yet found in Asia

country and its slowly changing climate, with all that such changes meant in abundance or scarcity of the necessities of life, constituted an environment that must have had a profound influence on the primitive human tribes, and may have been a major factor in compelling their migrations.

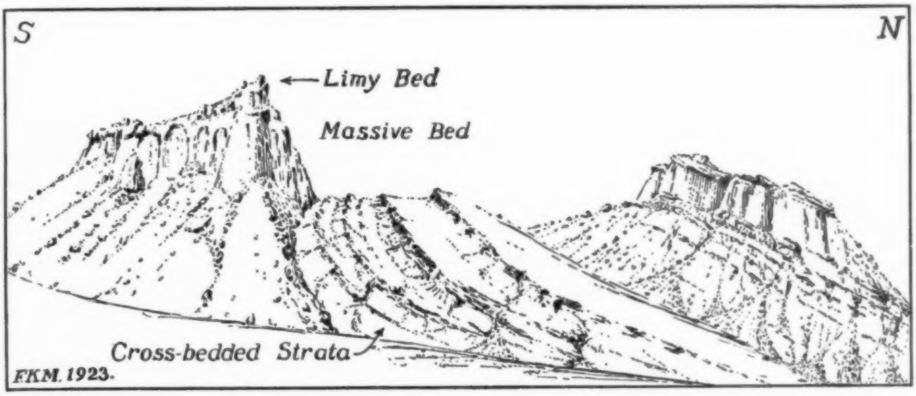


Fig. 5.—Field sketch of the dinosaur beds at Djadokhta. The sloping layers at the base of the picture are part of an ancient sand dune which was formed during the Age of Reptiles. The towering pillar at the left is a remnant of a bed of fine wind-blown sand. The rocks indicate a semi-arid climate at the time the dinosaurs lived

Topographic Surveys

By L. B. ROBERTS

THE general advance of exploratory knowledge depends on the manner in which records of progress are made available for others to use. This information is best understood when presented in map form, becoming, in reality, an intelligence document.

The topographic work accomplished as one of the many activities of the Central Asiatic Expedition to Mongolia during the field season of 1925 serves primarily as a base, on which information obtained by the various members of the party can be made a matter of record, through overprints, and can supplement their written reports.

Two classes of maps were produced; first, a topographic route map, to scale, of every mile traversed, constructed as a continuous line from Kalgan, the starting point of the 1925 Expedition, to the most western point reached on the traverse; second, a more detailed small scale topographic map of those localities of special interest where important scientific evidence was obtained.

The plane table method was used in all mapping work, orientation being obtained independently of magnetic compass bearings by means of the Baldwin Solar Chart. Distance was obtained, on the route traverses, by automobile speedometer, an adaptation of the perambulator method used with considerable success by British exploratory parties.

Differences of elevation were secured by vertical angles; and it is believed that elevations are reasonably correct. Because of disturbed local conditions, it was not possible to complete the route map as a closed circuit, and the line is not checked.

On such work as in this area, a topographer contends constantly with wind and wind-blown sand, with extremes of heat and cold, with distorted images and mirages; and he must be alert to adapt all known topographic methods to the conditions imposed by constantly changing circumstances.

Bearing of Palæobotany on Habitat Conditions in Mongolia

By R. W. CHANEY

FOSSIL plants, like those now living, furnish the most reliable information as to habitat conditions. Unlike land animals, the plants of the land are held in place by their roots, and cannot escape to more favorable situations during seasons of drouth or temperature extremes. Their existence at a given point indicates an ability to withstand all the conditions there over a considerable period of years, which in the case of trees commonly reaches one or several centuries.

Most of the fossil plant material collected in Mongolia is in the form of petrified tree trunks. None of these has been finally identified but, from the small size and twisted stems of many specimens, it is clear that they are related to the trees now living in the semiarid parts of the world, where conditions are not favorable for tree growth. The more delicate plant structures, leaves and fruits, are for the most part absent from the Cretaceous and Tertiary sediments of Mongolia. As they fall from the trees today, these structures become dried and decayed, except in regions of standing water, where they mingle with the sediments and leave their impression in the resultant shales and sandstones. The scarcity of such impressions in the sediments of Mongolia suggests that its past climate was too arid for the presence of many permanent water bodies. At the two places where leaf impressions have been found, in the Cretaceous at Ondai Sair and in the Pliocene or Pleistocene beds at Hung Kureh, the plants represented are of aquatic types not greatly unlike some of those living on the borders of Orok Nor today.

The Most Significant Fossil Finds of the Mongolian Expeditions

By W. D. MATTHEW AND WALTER GRANGER

PERHAPS one may best sum up the importance of the fossil finds in Mongolia as the discovery of a new continent. New, that is, to palæontology. For while the present geography of Asia and its existing animals are fairly well known, the record of its past animal life was almost a blank page. We knew a good deal about the extinct animals of India, especially in the later Tertiary, and a marvelous series of faunas they were. But the animals of India are, and probably were in times past, very different from those of Asia north of the Himalayas. It is and was a distinct geological region. We knew a little about the Pliocene and Pleistocene animals of China, chiefly based upon fossil teeth and bones purchased in Chinese drugstores, where, under the name of dragon's teeth and dragon bones, they have long been sold for medicine. Of the earlier record of land animals in Asia nothing was known. It was a land area of great geological antiquity as well as of vast size; so much had been shown by geological exploration. Its past relations, geographic and faunal, to Europe and North America, to India and Africa, were a subject of fascinating specula-

tion and of theories which, however strongly supported by inference and indirect evidence in the geology and faunas of these other continents, cried aloud for the crucial test of a few direct facts which would show whether or not they were sound.

Well, now we have the facts. Not all we should like to have or hope to get, but a very substantial body of them, sufficient to get a pretty good "line" on the characters of the successive faunas that inhabited Central Asia during the Cretaceous and Tertiary periods. One hundred and ten new species of fossil mammals and reptiles have already been described from the collections of the Central Asiatic Expeditions. Most of these belong to new genera, a few even to new families. They represent ten distinct successive faunal stages in the Cretaceous and older Tertiary, the largest and latest fauna being the Hsanda Gol *Baluchitherium* beds with more than thirty species.

To this evidence must be added the important results of the Chinese Geological Survey collections in the later Tertiary of North China, and those of the Russians in the Kirghiz and eastern Siberia. All in all we have now a pretty fair record of the extinct animals of Central Asia during the Cretaceous and Tertiary.

Probably the most important of these Mongolian discoveries, certainly the most interesting to the general public, is the Cretaceous desert fauna of Shabarakh Usu. This is the famous dinosaur egg locality, and it is the eggs, a familiar object in a very strange association, that appealed to everybody's imagination. They were really important scientifically, for it was the first positive proof that dinosaurs laid eggs, or at least that this kind of dinosaur did, for 'dinosaur' like 'pachyderm' includes a wide variety of animals, no more nearly related to one another than are a hippopotamus and an elephant. To the scientist the skeletons and skulls of the dinosaurs that laid them are of more importance than the eggs themselves, and a series of twelve skeletons and more than seventy skulls in all ages from newly-hatched young to adult makes this at present the best known type of dinosaur—even better than the famous *Iguanodon*. Four or five other kinds of dinosaurs and some smaller reptiles are also represented by skulls and skeletons. But of even greater interest to science are half a dozen tiny mammal skulls, the largest only an inch long, found in this same formation. Mammals of the reptilian era are excessively rare and, with one exception, nothing better than parts of jaws and teeth had ever been found. These skulls will increase greatly the scanty evidence as to the origin and earlier evolution of mammals.

Another large dinosaur fauna found at Iren Dabasu is of much scientific importance although of less popular interest. Preliminary studies indicate it as probably ancestral to the great Cretaceous dinosaur faunas of North America.

The earliest Tertiary fauna is the Gashato, of Palæocene age, and of curious and rather unexpected character. We had expected to find in this horizon the ancestors of the four-toed horses of North America and Europe. Instead we found the ancestors of certain South American ungulates whose origin had been equally obscure, but which we had expected to find in North America rather than in Central Asia. With these we find the ancestors of the giant uintatheres of North

America and a variety of other interesting small mammals.

Then there are three successive mammal faunas of the later Eocene. These include some large rhinoceroses and titanotheres so closely related to the American species that they have been placed under the same genera, and a considerable variety of smaller animals, also prevailingly American in relationships. Among them is the most gigantic of the Carnivora, *Andrewsarchus*, related to the American *Mesonyx*. In the latest of these Upper Eocene faunas appears the first of the ruminants, ancestral probably to those of the Oligocene of Europe and North America. But it is remarkable that we find no trace in the Eocene of Mongolia of the four-toed horses of the American, or of the palæotheres of the European Eocene. In their place occur various small, slender-limbed animals related partly to tapirs, partly to rhinoceroses, but not closely to either group.

Two Oligocene faunas follow; a third probably has been added by explorations of 1925, but the collections have not yet been studied and compared. The Lower Oligocene Ardyn Obo fauna contains the last of the titanotheres, nearly related to its American contemporaries, also various rhinoceroses, large and small, primitive Carnivora and a few rodents. The affinities of this fauna are rather more European than American.

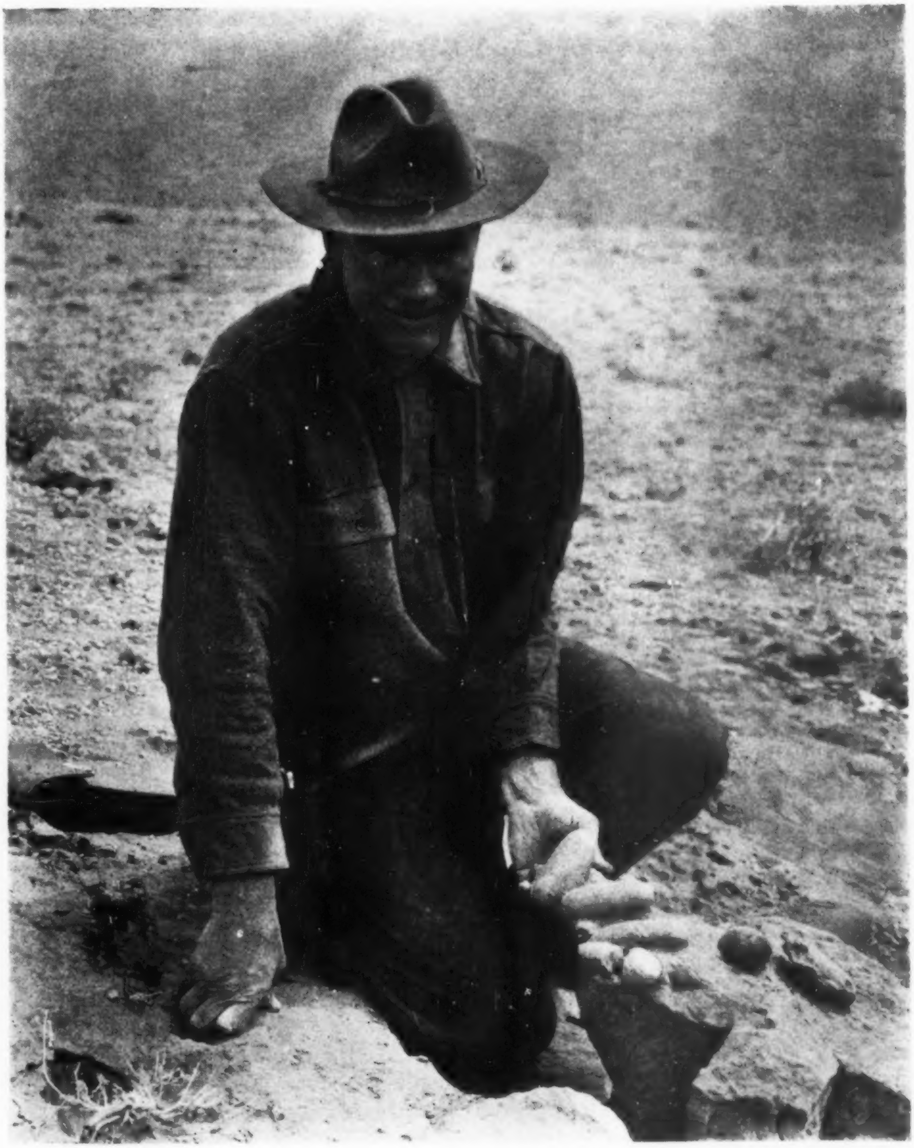
The Middle Oligocene Hsanda Gol contains the giant rhinoceros *Baluchitherium*, a beast as large as an elephant, but in proportions a long-legged, long-necked rhinoceros, hornless and rather small-headed. The rest of the fauna consists of a few medium-sized and many small mammals, mostly Carnivora and rodents, some of them represented by many hundreds of jaws, others comparatively scarce. A few insectivores, intermediate between tree shrews and jumping shrews, are of unusual interest, as so little is known of the fossil history of these animals. Many of these carnivores and rodents are related to European Oligocene animals; some to American, and one or two find their nearest relatives in Africa. Rabbits are very abundant, but they are related rather to the Old World picas than to the New World true hares.[1] Here, too, we find the earliest true deer (*Eumeryx*), ancestral to the Miocene deer of Europe and North America.

Here then is a series of fossil faunas Cretaceous and Tertiary in age, from a region unknown to palæontology. They are represented not by a few fragments but by a great series of specimens, finely preserved skulls and skeletons, thousands of jaws, articulated limbs and feet, and so on. A few of them we have noted by name, but it is in fact the entire series of faunas, the light that they throw on the climate and conditions of Asia, the relationships and origin of various races of mammals and reptiles and upon numerous related problems; it is the whole of this large addition to scientific knowledge that is important, far more than any selected features. The dinosaur eggs, the giant *Baluchitherium*, or the huge carnivore *Andrewsarchus*, are of more popular interest but of no more scientific importance than the inch-long Cretaceous mammal skull or the equally tiny tree shrew skull with its possible bearing upon the origin of the Primate order.

[1]Old and New World respectively in origin, but each group has invaded the homeland of the other.

Scenes and Activities in Mongolia[1]

PHOTOGRAPHS TAKEN BY THE CENTRAL ASIATIC EXPEDITIONS OF THE AMERICAN MUSEUM OF NATURAL HISTORY
DR. ROY CHAPMAN ANDREWS, LEADER



THE LEADER OF THE EXPEDITION INSPECTING A NEST OF DINOSAUR EGGS

The first dinosaur eggshell was found by Granger at Shabarakh Usu in 1922. The first nest was discovered by Olsen in 1923, and during the season several additional nests and many individual specimens were recovered. Olsen scored again in 1925, bringing in the first eggs of the season. Andrews is seen with this find, which was the first proof that the vigorous search of 1923 had not exhausted the supply

THE SUMMIT OF WAN CH'UAN PASS

Through a breach in the Great Wall between China and Mongolia a caravan trail enters the desert basins of Central Asia. The Expedition cars are seen in the gap, beside a ruined watch-tower of the wall, which follows the edge of a scarp of basalt forming a natural strategic boundary for many miles. The terraces, at the extreme left, are the approach to a small Buddhist temple. Here devout travelers are wont to tarry before venturing into the vast lonely stretches of the desolate interior

THE STAFF AT BREAKFAST

At breakfast and dinner the members of the staff were wont to assemble in the great tent and plan the day or recount adventures. Granger, Morris, Shackleford, Chaney, Butler, and Young face the camera; Robinson, Lovell, Nelson, Loucks, and Olsen face away. Andrews, Roberts, and Berkey are not in the view. The tent carries characteristic Chinese designs, the central one being the long life symbol, and this is surrounded by five conventionalized forms representing the bat, a symbol of happiness. The design along the ridge pole is a combination of swastikas, bats, and lotus flowers

THE TOPOGRAPHERS MAPPING THE VALLEY OF SHABARAKH USU

Chief topographer Roberts, at the right, records the observations made by Butler with the Gurley transit. At the left, Robinson, as rodman, uses a camel to speed up the taking of stadia-readings. In the background, beyond the native yurts, are eroded remnants of ancient sand dunes which rest upon still older deposits made by a sand-choked stream at the close of the Ice Age. Here were found thousands of stone artifacts, left by a vanished race of primitive man

GRANGER AT ULA USU, PREPARING A TITANOTHERIUM SKULL FOR SHIPMENT TO NEW YORK

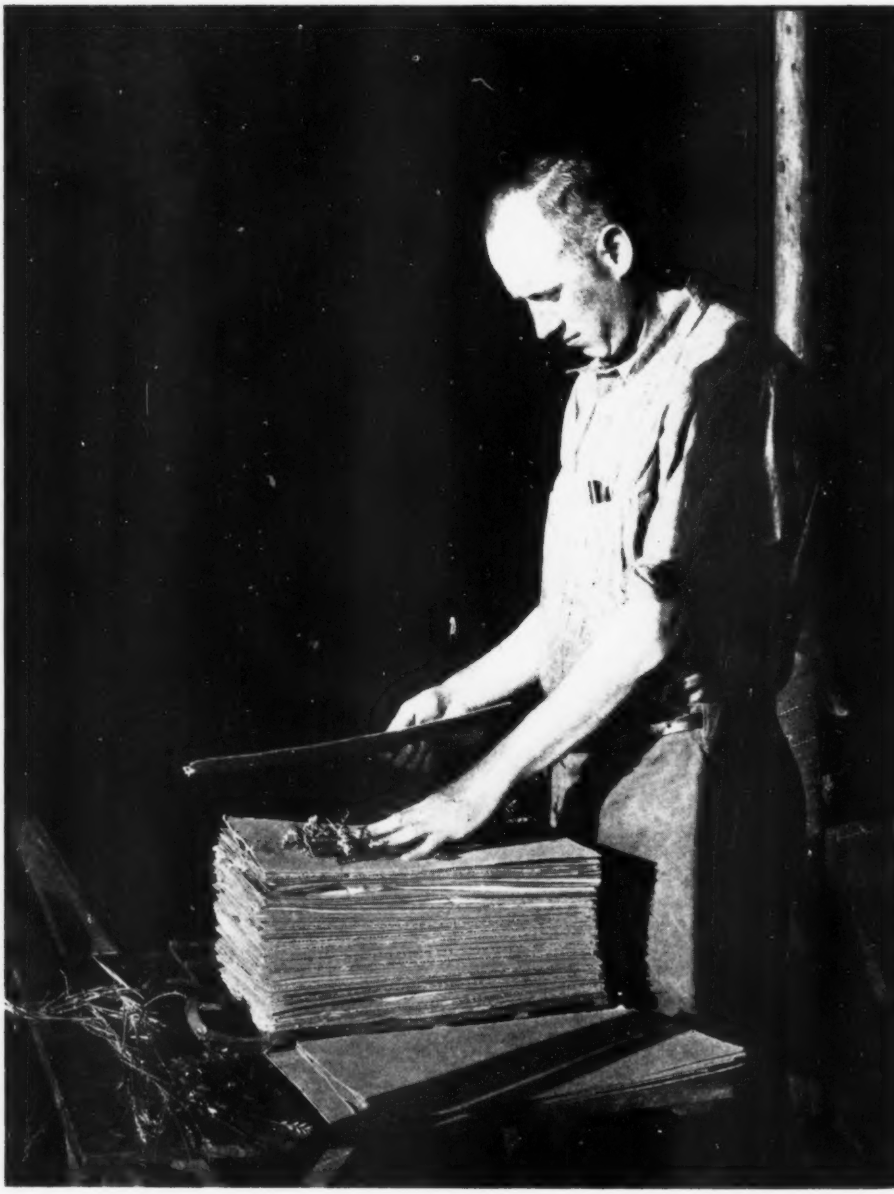
These fossil bones of Eocene age often crumble when uncovered. To preserve such specimens, the bone is first soaked with gum arabic, which cements the particles together; then Japanese rice paper is stippled on with a brush. When this has dried, the specimen is bandaged with strips of burlap dipped in flour paste, which hardens and prevents breakage on the long trip to the American Museum of Natural History

THE SEDIMENT BASIN NORTH OF THE ALTAI RANGE

The photograph was taken from the mouth of Tiger Cañon which dissects the northern face of the Baga Bogdo mountain-block. The distant skyline is the Mount Uskuk block of ancient crystalline rocks. In the foreground are three terraces, marking three pauses in downward-cutting, corresponding to as many recurrent changes in the climate of the region. This is the Tsagan Nor basin, lying between Mount Uskuk and Baga Bogdo, one of the largest and most productive of scientific results found in Mongolia. In the distance, near Mount Uskuk, lie the collecting stations, Ondai Sair and Loh, where literally thousands of fossil specimens were gathered, ranging from lowest Cretaceous to Miocene age. The steep-sided, flat-topped hills at Hung Kureh, in the central distance, are composed of sediments washed from the uprising mountain range during the Pliocene and Pleistocene periods Fossils of deer, ostrich, mastodon, and horse were found here, those of the horse being the oldest bones of its race thus far discovered in Asia

OLSEN DIGGING OUT THE LEG OF A TITANOTHERE

This is a typical Gobi Desert scene. The view is taken at Ula Usu in the Shara Murun district, about 300 miles northwest of Kalgan. Early Tertiary sediments underlie a great stretch of country and are eroded to bad-land form at many places, baring great areas of sediments to the search for fossils. From Ula Usu an especially fine lot of material of Eocene age was recovered. This spot was discovered in 1922, and extensive collections were made during the seasons of 1923 and 1925



PLANT COLLECTING IN THE GOBI

Chaney, the palæobotanist, finds a greater number of living plants than fossil forms. The traveler is always surprised at the variety to be found in so arid a region, which, to the casual observer, seems almost barren. There is, in places and at times, a wealth and beauty of vegetation that surpasses belief. About five hundred different species were collected during the 1925 season

Each fossil shell or bony fragment lures the imagination of the finder to picture the creature as it lived, its surroundings and associates, but as the writer stood within the ruins of the most celebrated school of the ancients and picked up this fragmentary elephant tooth there was an added stimulus, for it seemed to come from the invisible hand of the master Hippocrates, passed on as a problem unsolved by his philosophy. (Photograph is natural size)

Is This the Earliest Known Fossil Collected by Man?

By BARNUM BROWN
Associate Curator of Fossil Reptiles, American Museum

THIS small elephant tooth, identified as a milk molar of *Elephas antiquus,* is priceless because of its association, having been collected by the ancients more than 2000 years ago. Indeed it may have been handled and discussed by Hippocrates himself, for it was dug up where I found it among the pieces of statuary and figurines in the ruins of the famous Asklepieion, the medical school where he prosecuted his earlier studies.

Cos Island, in the Ægean Sea, lies close to the mainland of Asia Minor opposite Halicarnassus. Here are two small exposures where the Pliocene fossils *Hipparion, Bos,* and *Elephas* have been found—a thirty-acre area three miles southeast of the town of Cos, and another area of equal size one-half mile west of Cardamina on the south shore near the middle of the island, about ten miles westward.

Asklepieion, the ancient medical school, was located approximately midway between these points on the slope of Mount Prion, and it is evident that the fossil had been carried there in ancient days, for it was covered by débris in the ruins of one of the larger buildings.

Hippocrates has been called the father of medicine, for he was the first to introduce principles of inductive philosophy in the practice of medicine, which previous to his time had been a system of superstitious rites practiced wholly by the priests. He was born on Cos Island in 460 B.C. and his famous medical school flourished long after his death, but the Asklepieion was a ruin before the Christian era, so I believe this to be the first recorded instance of a fossil having been collected by man.

FELTONS HARBOR ON NORTH SHORE OF RIO GALLEGOS, ARGENTINA, SHOWING MUD BARS EXPOSED AT LOW TIDE

Fossil Hunting in Patagonia

By ELMER S. RIGGS
Associate Curator of Palæontology, Field Museum of Natural History, Chicago

PLANS for a palæontological expedition to Patagonia were first laid by the writer many years ago when a student-member of a field party under the late Professor Williston. Inspired by the enthusiasm of this great teacher, my intimate friend Barnum Brown and I had, out of the wide opportunity of college activities, chosen to follow the lure of palæontology. In the first flush of boyish zeal we canvassed the field of possibilities from Alaska to Patagonia. And so, lying awake in our bunks among the sagebrush of Wyoming to enjoy the coolness of a desert night, and looking up into the starry canopy above, we planned an undertaking which each of us was sooner or later to carry out under the constellation of the Southern Cross.

Toward the close of the year 1921, renewed activities of the Field Museum, backed by the generous support of Captain Marshall Field, made it possible to revive these plans. A series of expeditions to South America, covering a period of five years, resulted. The purpose of these expeditions was to make further studies of the geology of Argentina and of adjacent states, and to bring together collections of fossil mammals. These mammals belong to a unique system of animal life which had its earliest known dispersal in an ancient continent of which Patagonia is only a vestige.

A field party consisting of two collectors of wide experience in palæontological work, Mr. J. B. Abbott and Mr. G. F. Sternberg, under the leadership of the present writer, sailed for Buenos Aires in November, 1922. The party was courteously received by the director and the scientific staffs at the Museum of La Plata, and at the National Museum of Buenos Aires. Many favors were extended by scientists and by citizens throughout Argentina. American and British citizens at Rio Gallegos not only extended courtesies but lent substantial aid to the expedition in many ways. With the assistance of these new-found friends the work of the expedition was well and favorably begun.

Patagonia has long been a field of particular interest to naturalists. Early in the nineteenth century came Darwin as a young man on the famous *Voyage of the Beagle*. Later the Argentine pioneer naturalists, the Brothers Ameghino, and others from Europe and from North America followed. The task of the present expedition was therefore not one of exploration, so far as the Santa Cruz formation was concerned, but one of making a representative collection from a well-known region, and to accomplish this within a limited time.

The Santa Cruzean formation, as exposed in the cliffs along the eastern Patagonian coast, is about 300 feet in thickness. Fossils were found in these cliffs at almost all levels. However, the steepness of the cliffs often rendered them inaccessible to men working on foot. Landslips have from time to time carried down acres of the pampa and left the earth piled up in great windrows at the shore. The waters of the inrushing tide, rising to a maximum of fifty-eight feet, dissolve and carry

The Santa Cruz formation exposed on the north shore near Rio Gallegos, Argentina

away these clays. The sands are more slowly carried away and distributed over the sea bottom. The gravel and harder masses are left to accumulate on the beach, but are slowly worn away. Great blocks of stone are moved and ground together by the waves and are slowly disintegrated. In short the tide flat is a great natural sorting-pan; the waves as the moving agent, select and distribute the material according to mass and gravity.

Along these flats careful search reveals the fragments of fossil bones laid bare in this process of degradation. We find them as little brown fragments, broken and mingled with the gravel. We find them appearing like the broken ends of brown and hollow rootlets exposed at the surface of the fallen blocks of stone, accumulated at the shore. We find them exposed in the ledges of sandstone and in the layers of clays on the tide-flats where twice daily they are swept clean by the

Camp of first Captain Field Palæontological Expedition at Estancia La Costa, Santa Cruz, Argentina

advancing and retreating tides. We find them exposed in the steep faces of the cliffs where access is difficult and where the glare of sun on whitened surfaces sometimes drives one blinded and dizzy from the task. In this work there is no fixed rule and no guiding landmark. The collector must carefully, foot by foot and mile by mile, go over the more promising stretches. In so doing, success in every varying measure rewards his efforts.

The roadways along this Patagonian coast in many places run parallel to the shore but usually several miles inland, —beyond the obstructions offered by estuaries and the bluffs of stream-valleys. Through long stretches the height and the steepness of the sea-wall make approach to the shore impossible. Once in ten miles or more our party found valleys of small streams which offered passageway for men on foot and often for saddle-animals. Once reached, the hard sea-sand at low tide, offered a safe and convenient passageway up and down the shore for men and for saddle-horses. By this means, the shore exposures were worked eight or ten miles each way from camp bases.

The means of transporting specimens from the shore to the nearest point for loading upon vehicles, offered many problems. The specimens were usually brought together on shore by man-power and cached above the reach of tidewater on some bench of erosion or of landslip. From these points they were sometimes borne to camp on saddle-horses. On one occasion the curved fragment of a broken rowboat was made use of as a sledge and with specimens loaded upon it was drawn along the sand by a horse at the end of a saddle-rope. Boats on the open sea were not to be thought of, but on the estuary of the Rio Gallegos, a dory was made use of for this purpose.

Excavating a specimen in the Santa Cruz formation at Rio Coyle, Argentina

Members of the Captain Field Palæontological Expedition and their host and hostess at the Meteorological Station, Colonia Sariniento, Argentina

At the south side of Rio Coyle, where the stream valley approached the beach without more obstruction than a wide stretch of loose gravel, a light motor car was brought to the beach by the aid of man-power. Once on the hard sea-sand this car was employed to speed rapidly along the tide-flat for a distance of ten miles and return with a load of four hundred pounds of specimens. Returning again, this operation was repeated five times between tides, and the accumulated cargo and machine safely removed from the beach before the next high tide.

On the north side of Rio Coyle conditions were less favorable for such operations. Specimens discovered some miles from the shore in a wide bush-covered basin, were to be conveyed to Estancia Coyle. A considerable embankment of sea gravel thrown up by the waves at high tide prevented approaching this basin from the shore. A continuous rim of cliffs some two hundred feet in height offered a similar barrier from the land side. The course of least hazard was decided upon. With rope and tackle the little car was let down the steep slope from above. A road was cleared across the basin and the specimens conveyed to the shore. There they were unloaded, the car again pushed across the gravel barrier by man-power, and the return along twenty miles of shore sand was begun.

In this last undertaking, rapid travel over hard, wave-marked, sand caused such a vibration in the car that a break in the front gear resulted. This occurred on the second trip of the morning, with a car loaded with specimens, and only an hour's margin of safety before the incoming tide would sweep over these sands to a depth of thirty feet. The needed "spare parts" were not at hand. Unless repairs could be made within the hour both car and specimens would be lost. The situation was met by driver and mechanic hurrying ashore, making a fire of driftwood, and doing a hurried piece of blacksmithing before the returning tide should overtake them.

The collectors of the party spent the first winter near Comodoro Rivadavia. As soon as the rains of late winter had somewhat abated they broke camp and set out to reach the Rio Chico. The locality which the Amherst Expedition in 1911 had found so productive in fossils of the *Pyrotherium* zone was the first objective. The way lay across a pampa two thousand feet above sea level which had recently been covered with heavy snow. After one unsuccessful attempt, and after spending two nights on the high pampa, the desired locality was reached.

A single tent protected by thorn-bush barricades as a shelter against wind and snow, constituted the camp. This was located in an open valley dotted by occasional buttes of the Patagonian formation. A single butte a half mile in length had preserved a section of an old channel deposit. In this butte fossils were found in limited quantities. The intensive work of the Amherst Expedition had left few specimens to be found.

The collectors were impatient to move on to new fields. A new supply of plaster of Paris now enabled them to take out a rare specimen of fossil bird and other specimens which had been discovered there. After spending another week in reconnoissance along the valley, a move westward to the region of lakes Coluhuapi and Musters was decided upon. A flooded stream and boggy roads made the valley of the

Rio Chico impassable. It was therefore necessary to return to Comodoro Rivadavia and to approach the lake region from the southward. Renewed rains again held the party inactive through the month of October. Valuable time was thus lost before supplies could be forwarded and the move toward Colonia Sarmiento begun.

One of the great dinosaur bones of the San Bernardo Hills, Chubut, Argentina

We camped at the source of the Rio Chico, where that stream issues from Lake Coluhuapi; gray shale bluffs were observed on either side of a narrow valley. After an hour or two of prospecting late in the evening of our arrival, Mr. Abbott returned to camp to report the occurrence of fossil dinosaurs in the gray shales. Somewhat dubiously he also announced finding evidence that another collector had been there before us. Together he and the leader of the party visited the locality of his discovery next morning, and found in a small cañon evidence of earlier work.

Bones of large dinosaurs had been dug out of the shale of the hillside and piled up in heaps on a level area at its base. Leg bones, pelvic bones, and vertebræ, all broken into many pieces, had been carried some distance and piled up, the pieces of a single bone constituting a pile. There they were found, without wrappings and without mark, to indicate ownership. Subsequent rains had washed mud from the hillside over them; sun, rain, and wind had weathered them so that they were now falling into decay. Three or four thousand pounds in all, this accumulation represented no small labor on the part of an earlier collector. Inquiry made of the oldest settlers failed to reveal who the collector was, or in what year his work had been done.

Some days later a deserted camp was encountered near the old fossil-cache. A ring of stones marked the outlines of a bush-shelter, or *tolda*, such as were earlier constructed by the Indians of this region, and which are still employed by the shepherds for temporary camps. A drift-pick, a shovel, and two hammers, all bearing the mark of a Sheffield tool-maker, together with a ring-bolt and the iron handles of a chest, offered the only clue. The shovel blade was rusted through from the waters of rains and of melting snows which had been caught in its concave surface. The ashen handle was old and weathered. The less durable hickory handles of pick and hammer had rotted away. Many years had certainly passed since this unknown devotee of science had done his work and had, perhaps, passed on in search of carts to remove his treasure to a seaport one hundred miles away. At any rate, no grave or other mark was found to indicate that serious mishap had befallen him.

The outcrops of the Deseado formation at Lake Coluhuapi offered some

promise of fossils. Camp was established on the shore of the lake, in an adobe house, near the home of an Italian-Argentine fisherman. Saddle-horses were procured and search along of *Pyrotherium*. Just enough fragments of these animals were found to add zest to the search. Molar teeth of the former, having a grinding surface more than three inches square,

Collecting in the *Pyrotherium* beds, Rio Deseodo, Argentina

the neighboring escarpment was pushed for several days. In the course of this work an old cart track leading from the shore toward the bad-land hills was discovered, and repaired in places where washouts had made it impassable. The motor truck was then brought into use to convey the members of the party to the scene of the day's collecting. By frequent use of pick and shovel this roadway was extended eight or nine miles into the bad lands from which point the work was continued on foot.

In this locality the Deseado formation has a thickness of perhaps six hundred feet. This consists of strata of clays, and of sandstone. In the upper strata were found the teeth, tusks, and various bones of the gigantic mammal, *Parastrapotherium*. Another large, and equally strange beast bears the name

broken jaws, and tusks thirty inches in length, proclaimed the unusual size and character of this little-known form. Isolated jaws of the second great animal had been discovered by Ameghino forty years ago, but as yet no complete head has ever been found.

A more prolonged search resulted in the discovery of a fossil forest. The first indication of this was encountered in the form of a fossil pine cone brought out by the keeper of a roadhouse on the shore of Lake Coluhuapi. The informant said that this specimen had been found sixty leagues to the southward. Some time afterward a station keeper on the south shore of the Gulf of St. George displayed two similar specimens which were said to come from twenty leagues to the westward. Again at a crossing of the River Deseado we had seen others which were said to

come from twelve leagues to the southward. Employing the owner of the last specimens as a guide, we traveled four days in a motor car to reach the goal, and this three months after the first specimens had been seen.

Having reached the locality in the vicinity of Sierra Madre y Higa, we found a considerable number of fossil trees, some with stumps standing, others lying prone with broken branches and cones scattered about them, revealing a forest of fossil *Arecaria* or Brazilian pines preserved on the site where it had grown. A large collection of these specimens was made.

A more surprising claim was set up by a gentleman of scholarly training who reported that he had examined the skull of a fossil man which had been found in the Santa Cruzean Formation at Passo Ibanyez on the Santa Cruz River. A further claim of a "buried city" on the shore of Lake Cardiel had led to another five-hundred-mile journey with less satisfying results. The skull of "fossil man" proved to be only a curious concretion; the "buried city" a natural lava dike which had been thrust up through clays of Cretaceous age, and had in turn been laid bare by erosion.

It may be said that the remote corners of the world are often favorable sources for extravagant stories. In our own country, Texas, California, and Alaska have in turn given out such emanations. It is not surprising that Patagonia should have held a similar position as a source of romance. The irony of circumstance has decreed that one of the most improbable of Patagonian stories should come true.

Rumor in the later nineties reported that a gigantic animal similar to the great Argentine sloth, *Mylodon*, had been seen in the "jungles" of southern Patagonia. Some time afterward a peon employed on a sheep farm visited a cavern near by and brought home and made a whiplash of a piece of dried hide which he had found there. As a result the scientific world was startled by a report that fresh bones, dried skin, and other evidence of a Mylodon-like animal had been discovered at the Cave of Ultima Esperanza. It was even asserted that quantities of cut-grass upon which the animal had fed were found in the cave. These reports were substantiated by a group of Argentine scientists. Their investigations added to the list of extinct animals the recognized name of *Grypotherium*, an animal which is probably more recently extinct than the Great Irish Deer of the fourteenth century.

NOTES

THE AMERICAN MUSEUM GREENLAND EXPEDITION

THE SCHOONER "MORRISSEY," bearing the Greenland Expedition of the American Museum of Natural History, sailed from New York on June 20, 1926, and returned on October 2, 1926. During this time approximately eight thousand miles were covered. The party visited a number of places on the west coast of Greenland, from Holstenborg in the south to Inglefield Gulf in the north (about latitude 77° 30′ N.). This being an "open year," due to a comparatively mild winter and an early spring, no serious difficulties with ice were encountered. There was continuous daylight from the time Davis Strait was reached in the first days of July until the first of September when the homeward journey was begun.

The collection made for the Museum consisted of mammals, birds, fishes, and invertebrates. The most important specimens are the narwhals, of which several adults, one young and two foetal specimens, were secured. These afford extremely valuable material for exhibition, for the study of the soft anatomy, and for osteology.—H. C. R.

ASTRONOMY

DR. CLYDE FISHER spoke on "Popular Astronomical Education in Europe and America" at the annual meeting of the American Astronomical Society held early in September at the Maria Mitchell Observatory, Nantucket, Mass.

PLANS FOR THE PROPOSED HALL OF ASTRONOMY, to be a part of the American Museum of Natural History as outlined in the Astronomy (July–August) number of NATURAL HISTORY, are developing in an encouraging manner. In this work Doctor Fisher is aided by Miss M. Louise Rieker as secretary and by Mr. Charles J. Liebman, Jr., as assistant.

BIRDS

THE RUWENZORI–KIVU EXPEDITION.—Mr. Frank Mathews, a member of the Ruwenzori Expedition, who returned to New York City in September to enter a medical school, reports that Dr. J. P. Chapin and Mr. DeWitt L. Sage, the remaining members of the Expedition, are working with success and undiminished enthusiasm. Chapin writes of his ascent of Mt. Kenia as follows:

"The two parts of the mountain where birds appeared most numerous are the mountain forest (subtropical) from 5600 to 8500 ft., and the groves of large trees just above the upper level of the bamboos, near 10,000 feet. The bamboos are relatively poor in birds, and so of course is the more open country above the timber line, where, however, there is a splendid sunbird (*Nectarinia johnstoni*), a small thrush (*Pinarochroa sordida*), a starling (*Cinnamopterus tenuirostris*), a buzzard (*Buteo augur*), a swift (*Micropus mel a africanus*, I think), and possibly a few other birds."

In a letter dated Nairobi, July 1, Doctor Chapin reports the collecting of complete material for a habitat group of the bird life of the great Rift Valley, which will include ostriches, bustards, jabirus, vultures, francolins, secretary birds, weaver birds, and other smaller species. This collection, together with color sketches, diagrams, and photographs has now reached the Museum.

CONSERVATION

NATIONAL PARKS IN THE EAST.—A movement is on foot to purchase from private interests 600 square miles of virgin territory on the boundary line between North Carolina and Tennessee known as the "Great Smoky Mountains" and to present the tract to the United States Government for development and preservation as a national park. In the Blue Ridge Mountains of Virginia about 400,000 acres are also sought for the same purpose. Since the creation of nineteen national parks in the West, out of the public land preserves, more than 2,000,000 people visit them annually. The establishment of national parks in the East will place within easy reach of the congested areas of population these great natural playgrounds.—C. A. R.

EXTINCT ANIMALS

THE CHILDS FRICK EXPEDITION IN THE MID-MIOCENE DEPOSITS OF SANTA FÉ, NEW MEXICO.—The 1926 field party in charge of Mr. Joseph Rak, assisted as last year by two members of the Museum's preparation department—Mr. Charles Falkenbach and Mr. Charles Christman (who was associated with Mr. Rak in the work the past winter at Barstow)—has enjoyed a particularly successful season, having forwarded twenty-three cases of specimens to the Mu-

seum to date. Mr. Frick joined the party in September and spent a fortnight with Mr. Rak in a reconnaissance of contiguous areas and a checking of the stratigraphy.

HISTORY OF THE EARTH

SEISMOGRAPH RECORD OF EXPLOSION AT LAKE DENMARK, NEW JERSEY.—The explosions at the United States Naval Ammunition Depot at Lake Denmark, New Jersey, on July 10, 1926, were recorded on the seismograph at the American Museum, some thirty-one miles distant. The wave undulations, when magnified a hundred times, are less than one millimeter in amplitude. Separate explosions were recorded at 4:28:00," 4:29:30" and from 4:31:00" to 4:34:00" P.M. Eastern Standard Time. Another explosion occurred at 5:06:30" P.M., The record of these local disturbances has been of service to representatives of the United States Bureau of Mines and the United States Geological Survey in their study of the disaster.—C. A. R.

MAMMALS OF THE WORLD

BLUE-NOSE SHEEP FROM THE CENTRAL ASIATIC EXPEDITIONS.—During the past summer a shipment of 391 mammals has been received from the Central Asiatic Expeditions. The most noteworthy specimens, in addition to 7 argali sheep, 7 ibex, and 6 wild asses, are a series of Bharal or blue sheep (*Pseudois nahura*), a male, a female, and one young. The Bharal is especially interesting scientifically and is new to the Museum's collections. This sheep is distinctive in that it is closely related to the goats in many respects. The face glands, which are found in all true sheep, are lacking in the Bharal, as in the goats. Another goatlike character is its greater length of tail. However, the Bharal has glands between the hoofs of the fore and hind feet, as in the sheep, whereas the goats have these glands in the fore feet only.

MORDEN-CLARK ASIATIC EXPEDITION.—This expedition continues to meet with success in its collection of the large mammals of Turkestan. A sufficiently large series of *Ovis poli*, the spectacular wild sheep of the Pamirs, has been obtained, and now the expedition is concerned with working its way out of the country preliminary to the return home.

Because of political troubles in China, which prevented carrying out the original plan of the Morden-Clark Expedition to join forces with the Third Asiatic Expedition at the close of work in the Pamirs, Mr. Morden and Mr. Clark have made plans to cross eastern China and Mongolia, coming out at Urga about the end of December. During the return, the party will spend a month in the Tian-Shan collecting, where they will get ibex and other interesting specimens of the mammals frequenting this high country.

AKELEY EXPEDITION.—Letters from the field report very satisfactory progress. On July 19 the party had already secured all of the material and data for the Klipspringer Group, accessories, paintings, and animals. Splendid specimens of giraffe, oryx, Grant's zebra, and Grant's gazelle have been obtained for the water-hole group. For the background of this group Mr. Akeley has picked a superb scene near the Abyssinian border, one of the few remaining strongholds of African large game. Here the members of the expedition met with the Samburu, the native wandering herders so well portrayed in Martin Johnson's motion picture film.

Mr. Eastman and Mr. Pomeroy have been very successful in their hunting for specimens of African game. Mr. Eastman secured a calf buffalo for the Buffalo Group, which was well under way at the time of writing. Mr. Pomeroy planned to join Mr. Akeley in a kudu hunt in Tanganyika at the end of August, hoping at the same time to secure material for a Bongo Group, if the animals were not too scarce

MARINE LIFE

BAHAMA ISLANDS EXPEDITION.—Dr. Roy Waldo Miner has just returned from an expedition to the Bahama Islands where he ecured casts of fishes to be used in connection with the Coral-reef Group for the new Hall of Ocean Life in the American Museum, and also sketches for the backgrounds for the upper portions of the same group. Mr. John S. Phipps, of Westbury, Long Island, generously contributed the use of his yacht, "The Seminole," and several subsidiary boats. His son, John H. Phipps, efficiently managed the navigation of the boats, and through his skill as a fisherman many specimens were secured.

Doctor Miner was accompanied by Mr. Chris E. Olsen and Mr. F. L. Jaques, artist. Mr. Olsen was assisted in making the fish-casts by Doctor Miner's son, Roy W. Miner, Jr. About one hundred casts and color

sketches of fishes were made and many studies of the reef surroundings.

Mrs. Miner also accompanied the expedition to secure photographs and moving pictures of the life and industries of the Bahaman natives both at Andros and Nassau. About 1500 pictures and 2500 feet of motion picture film were obtained.

During their stay the party experienced a narrow escape from a tropical hurricane.

A more detailed account of the expedition will appear in the next number of NATURAL HISTORY.

FISHES

BERING SEA.—During August Mr. J. T. Nichols made a short trip to Bering Sea to familiarize himself with the present physiographic, marine, and climatic conditions there, in so far as they may have influenced the distribution of fishes or other animals across this area in the past. His field observations suggest that the sculpins and salmons were of Pacific origin and reached the Atlantic across the Arctic Basin, that the cods gained the Pacific in the opposite direction, and that this would have been possible under conditions not very different from present ones. Fresh-water carps, on the other hand, probably crossed from Asia when the physiography and even climate were quite unlike the present. There is a considerable seasonal migration of salmon northward from the Pacific into Bering Sea, as evidenced by heavy catches in traps recently placed in the narrow pass between the Alaska Peninsula and Unimak Island.

THE ZANE GREY COLLECTION OF GAME FISHES.—Through the efforts of Mr. Van Campen Heilner, Mr. Zane Grey has presented to the Museum his large collection of mounted game fishes, one of the most complete collections of this kind in the world. The department is sending an expert to Lackawaxen, Pennsylvania, Mr. Grey's eastern home, to make arrangements for packing and shipping the collection to the Museum, for exhibition in the new Hall of Fishes.

THE NEW HALL OF FISHES.—Steady progress has been made in getting ready the new Hall of Fishes for the installation of exhibits. Most of the cases are completed. The series of seven scenes of deep-sea fishes by Mr. Dwight Franklin are about two thirds done. The color scheme for walls and cases has been worked out and a number of the wall-case exhibits have been arranged. Models for the Shark and Sailfish groups have been completed and work on these groups is in progress.

MINERALS

MURAL PAINTINGS FOR THE MORGAN HALL.—Mr. William S. Taylor, whose work on the walls of Alaskan Hall is familiar to all visitors to the Museum, is preparing a series of mural paintings for the Morgan Memorial Hall of Minerals. The excellent lighting and imposing setting of this hall will combine to furnish conditions for the most favorable display of Mr. Taylor's work, which will be done in a subdued key to harmonize well with its surroundings.

There will be a triple panel at either end of the hall, the middle panel of each group being over the entrance arch. There will also be two long rectangular panels on the south wall. The subjects of Mr. Taylor's paintings will be the Neolithic, Bronze, and Iron ages.

REPTILES

THE DOUGLAS BURDEN EXPEDITION TO THE ISLAND OF KOMODO.—Mr. William Douglas Burden, leader of the American Museum's Expedition to Komodo Island, Dutch East Indies, has reported singular success. The main object of the Expedition was to collect record specimens of the semi-mythical giant lizards of Komodo for a group in the new Reptile Hall in the Museum. The Expedition secured a large series of specimens of *Varanus komodoensis*, as the lizards are called, and has shipped two adult specimens to the Zoo alive. Their arrival in New York called forth considerable newspaper comment. They are not only the largest and most spectacular lizards in the world, but they should prove of great scientific interest in shedding light on the evolution of the large fossil Varanoids of Australia.

HONORS

THE JOHN PRICE WETHERILL MEDAL.—Carl Akeley, explorer and taxidermist of the American Museum of Natural History, has been nominated for the John Price Wetherill Medal of the Franklin Institute, for his invention of a moving picture camera designed for photographing wild animals.

APPEAL FOR BACK NUMBERS OF "NATURAL HISTORY"

THE LIBRARY of the American Museum receives frequent requests for complete files

of Natural History, which it is no longer able to furnish. Should any subscribers care to donate copies of earlier issues, the gift will be very much appreciated, and postage will be refunded to the donor. Address the Librarian, American Museum of Natural History.

NEW MEMBERS

Since the last issue of Natural History, the following persons have been elected members of the American Museum, making the total membership 9050.

Life Member

Mr. W. H. Carpenter.

Sustaining Member

Mrs. Ethel Bergstresser Stewart.

Annual Members

Mesdames: James A. Finn, Minot Simons, A. Solomon.

Miss: Lena F. Vanner.

Doctors: Harold Herman, A. Sulger.

Messrs: A. E. Carlton, Wm. Garelick, Robert Hager, Jr., Claude N. Hitchcock, S. B. Kanowitz, Charles C. Nobles, Geo. W. Reynolds, Y. Sasaki, Lyman D. Smith, George Van Santvoord, Albert C. Wappler, Richard S. Wormser, Rudolph Zinsser.

Master Sandro Tovelli.

Associate Members

Mesdames: Charles T. Ashman, B. P. Bole, C. W. De Long, Marjorie Lee Guest, John N. Tidd.

Misses: Orrel M. Andrews, Annie Celeste Cutter, Elisabeth Ireland, N. B. Kimber, Vesta M. Rogers.

Prof. Wilhelm Segerblom.

Doctors: J. F. T. Berliner, E. H. Cushing, A. J. T. Janse, Philip W. Smith, John A. Wilson.

Captain J. A. Judge

Messrs.: John L. Atlee, William Howard Ball, James A. Bell, W. F. Bradshaw, Edward B. Butler, George J. Cooke, Clarence E. Fox, Samuel P. Hayes, Jr., N. H. Heck, Charles W. Hills, Henrik Koppels, Eugene C. Kuniholm, David I. Modell, Sterling Rohlfs, Earl S. Rush, J. Allan Smith, M. V. Terry, Lewis M. Webb, Fred Wurm, Jr., Henry Anson Wylde.

THE MUSEUM EXPLORING

NOVEMBER-DECEMBER

Pliny E. Goddard, Editor

Dr. Roy W. Miner visited the Bahamas during the summer to secure specimens, color studies, and notes for the completion of the Coral Group. A hurricane visited the same locality. An illustrated article will give a vivid account of this trip.

Assistant Director Murphy cruised in the Mediterranean where there are birds above, fish below, and mammals on the surface of the sea. There are pictures and interesting text.

Associate Curator Nelson and Mrs. Nelson have been in Asia with the Central Asiatic Expedition two summers and a winter. The winter they spent in the upper Yangtze valley hunting for early man. Mr. Nelson writes interestingly and scientifically of the evidences of Stone Age man. Mrs. Nelson tells of her experiences with the living inhabitants.

Mr. H. E. Anthony, curator of mammals, presents some observations on the Indians of Ecuador. The country these people live in is better adapted for scenery than agriculture, but nevertheless supports a considerable population.

Mr. Erich Schmidt, a graduate student at Columbia University, undertook a research problem in archæology which he worked out in the laboratory of the Southwest. The field trip was financed by Mrs. William Boyce Thompson who personally assisted in the work of excavation.

Douglas Burden, a trustee of the Museum, went to the Grand Cañon and saw things in Arizona which tourists miss. Besides the deep cañon and sculptured mesas he saw where erosion has taken away enormous deposits in other geological periods.

How did the fishes of the North Atlantic get to the North Pacific without passing through tropical waters? Associate Curator Nichols discusses this from some observations made on a recent trip to Bering Sea.

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GEORGE H. SHERWOOD,
Executive Secretary.

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